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J. W. L. GLAISHER, M.A., Sc.D., F.R.S., President, in the Chair.

Lieut. Arthur Mostyn Field, R.N., H.M.S. "Dart";
Herbert Ingall, Champion Grove, Champion Hill, S.W.;
Henry Addenbrook Wassell, Addenbrook Villa, Love Lane,
Stourbridge; and

The Rev. Charles John Young, Stafford Place, Halifax,
were balloted for and duly elected Fellows of the Society.

Admiral E. Mouchez, Director of the Observatory, Paris,
was balloted for and duly elected an Associate of the Society.

Proposed Index to Observations of Variable Stars. By Professor
Edward C. Pickering.

For the last four years the Observatory of Harvard College has published an annual statement of the number of observations made during the previous year upon each variable star. In the fifth of these publications—to be published during 1888—it is proposed to give a statement of the number of dates of observation of each variable star during each year since its discovery. It is hoped that an index of this kind will be useful to astronomers, even if it cannot be made complete; but its value will certainly be much increased by the addition of every extensive list of observations which can be obtained for insertion in it. All who are interested in this department of astronomy are therefore requested to send to this observatory any information of the

kind above described which they may have at command. It is very desirable that the information should be received early in 1888, in order that the publication may not be unduly delayed.

Harvard College Observatory, Cambridge, U.S.A. :
1887, June 22.

On the Parallax of 61_1 and 61_2 Cygni, as obtained by the aid of Photography. By Professor C. Pritchard, D.D., F.R.S.

The computations for the parallax of the two components of this historical double star are now completed, subject to some possible slight revision of the numerical work.

Inasmuch as the present communication professes to be nothing more than a preliminary and provisional announcement, perhaps the most interesting form of making it may be to give a short citation from the Report of the astronomical work done at the University Observatory in Oxford during the past year. It will be seen in the sequel that it is not without some importance to add that the Report was approved and adopted by the Vice-Chancellor and other members of the Board of Visitors, including the Astronomer-Royal.

The following is the citation referred to :—

“The somewhat hazardous enterprise of attempting for the first time in the history of astronomy to obtain the distance of fixed stars from our earth by the aid of photography has been attended with success. The final results of the investigation have been placed in my hands only during the writing of this Report. The first observation was obtained on May 26 of last year, and the last was effected on May 31 of the present year. The intermediate computations were systematically continued during the interval. They involved the reduction of no less than 30,000 bisections of star-images, on 330 photographic plates, procured on 89 nights. Eight independent determinations of the parallax of the two components of *61 Cygni* resulted from all this work, and these happily indicate a substantial agreement between themselves, and afford other necessary proof of reliability. Astronomical photography is hereby placed on a secure basis as an efficient and exact exponent of the highest form of astronomical science.

“Simultaneously with these observations similar work has been in progress for the determination of the parallax of μ *Cassiopeie* and *Polaris*. These observations will now be treated on a less laborious scale. The photographic plates of the *Pleiades* have also been taken with the view of obtaining the accurate relative positions of about one hundred stars therein. The necessary triangulations have been commenced.

“The funds granted by the University have been sufficient notwithstanding the continuous activity, which requires a cor-

responding continuity of outlay. This grant, hitherto triennial, expires in December next. If the Board of Visitors see fit to request the University to continue this grant for five years, it would assist in enabling me to commence a valuable and extended class of work, which under other circumstances I should not be justified in attempting."

This last sentence was altered by the Board of Visitors into "to undertake for the University a share in the production of a photographic map of the heavens."

The details given above testify without further words of mine to the unwearied perseverance and intelligence of my two able assistants Mr. Plummer and Mr. Jenkins.

The following are the particulars of the final numerical results referred to in the foregoing citation:—

Parallax of 61₁ Cygni.

Parallax of 61₂ Cygni.

Determined from star $a = 0''.4294$

from star $a = 0''.4250$

$b = 0''.4228$

$b = 0''.4508$

$x = 0''.4441$

$x = 0''.4520$

$y = 0''.4194$

$y = 0''.4135$

Mean $= 0''.4289$

Mean $= 0''.4353$

Mean probable error of a single determination of

61₁ Cygni $= 0''.0136$.

61₂ Cygni $= 0''.0142$.

Mean distance of star a from $b = 2382''.20$

x from $y = 2066''.16$

Distance a to b fluctuates from $2380''.84$ to $2382''.89$

x to y

$2064''.80$ to $2066''.86$.

Oxford University Observatory:

1887, June 10.

*Postscript (June 24).—*The very important significance of the above figures is twofold:

1. That in order to arrive at exactness of angular measure in a photograph, and especially in a series of photographs carried through considerable periods of time, it is absolutely necessary that each plate should be considered as carrying with it its own scale, which scale may be slightly variable from night to night, or even during the same night. This fact is indicated by the small variations in the distances of the comparison stars a , b , and x , y from each other. This fact, however, is not peculiar to photographic plates, but exists (to a less extent) even in measures taken with the heliometer.

2. That if due regard be had to this slight variation of scale, photography, properly handled, gives reliable results, equal in accuracy and delicacy to those obtainable by any other known astronomical methods.

Since the writing of the foregoing very succinct and provisional account of work recently completed at the University Observatory, Dr. De la Rue, with that munificent generosity which he has so often exercised for the promotion of knowledge, has promised the pecuniary means of adding a photographic telescope or camera to the large Refractor in that institution. The condition attached to this gift is the compliance of the University with the request made, as above stated, by the Board of Visitors. Oxford, therefore, may now be expected to be associated with Greenwich in the production of the great international photographic chart of the heavens projected at the Paris Conference.

A Comparison of the Star-Places of the Argentine General Catalogue for 1875 with those of the Cape Catalogue for 1880, and with those of other Southern Star Catalogues. By A. M. W. Downing, M.A.

In making this comparison the places of those stars which are common to the Argentine General Catalogue and the Cape Catalogue for 1880, as given in the former, have been brought up from 1875 to 1880, and the differences, Cordoba—Cape, taken. Proper motion has been applied in forming both the Cordoba mean places for 1875 and the annual variations in all those cases in which a proper motion is given in the Cape Catalogue, the quantity of proper motion being taken from the latter. The mean epochs of the two Catalogues are, however, so nearly identical that this element can have no sensible effect on the result deduced from such a large number of stars as is the present. In combining the separate differences, formed as is explained above, each hour of R.A. has been taken by itself, and the stars occurring in each hour arranged in order of N.P.D., and then the means taken over zones 10° wide for the extremes, 90° — 100° , 100° — 110° , and 170° — 180° , and 5° wide for intermediate N.P.D.s. In this manner the table (Table I.) has been formed, exhibiting the values of Cordoba—Cape, both for R.A. and N.P.D., corresponding to each hour of R.A. and to each zone of N.P.D., and the number of stars (always the same for $\Delta\alpha$ and $\Delta\delta$) in each group. It will of course be understood that the R.A.s of these two Catalogues depend on different systems of time-stars. In the formation of the Argentine Catalogue the star-places of the *American Ephemeris* for the different years were used; the Cape R.A.s depend on the annual lists of fundamental stars issued from the Greenwich Observatory.

The next table (Table II.) is formed by taking the means of the differences occurring in each horizontal line of Table I., and thus forming the mean difference in R.A. and N.P.D. over the whole range of N.P.D. corresponding to each hour of R.A.

The next table (Table III.) is formed from the means of vertical columns in Table I., and exhibits the mean differences in R.A. and N.P.D. over the whole range of R.A. corresponding to the different zones in which the N.P.D.s have been combined. To enable the reader better to estimate the range of the discordances in R.A. the differences corresponding to each zone of N.P.D. are given reduced to the equator, as well as the actual mean discordances at the different N.P.D.s.

It will be noticed that there is a remarkable break of continuity in the value of $\Delta\delta$ (as exhibited in Table III.) corresponding to the zone 140° — 145° , and in that corresponding to 145° — 150° , the value being $+0^{\circ}.088$ for the former, and $+0^{\circ}.006$ for the latter, or $+0^{\circ}.054$ and $+0^{\circ}.003$ respectively, expressed in equatorial interval. As the former of these mean differences depends on 1,229 stars, and the latter on 1,179 stars, this break cannot be considered accidental, and the general agreement is so good (except for stars in the immediate neighbourhood of the pole) that, though the actual quantities are small, the attention is arrested by the abrupt change.

The negative differences in N.P.D. appear to increase in magnitude as the northern limit is approached, being $-0''.73$ for the zone 90° — 100° . The difference for the zone 165° — 170° is also abnormally large, though depending on a considerable number of stars.

It will be remarked that the mean discordance in R.A. is $+0^{\circ}.047$ ($+0^{\circ}.036$ reduced to the equator), and in N.P.D. $-0''.40$, and that the total number of stars used in the comparison is 11,752.

The next step has been to obtain the values of $\Delta\alpha$ and $\Delta\delta$ for the beginning of each hour of R.A. and for each 5° of N.P.D. by means of a graphical representation of the changes of these values taken from Tables II. and III., it being assumed that the mean value corresponding to a certain hour of R.A. or to a certain zone of N.P.D. refers to the middle of the hour or of the zone. The $\Delta\alpha$ s and $\Delta\delta$ s read off from their appropriate curves for the beginning of each hour of R.A. have been respectively corrected by the quantities $-0^{\circ}.047$ and $+0''.40$ (the means, with reversed signs, of the $\Delta\alpha$ s and $\Delta\delta$ s taken throughout), so that the difference Cordoba—Cape for any given R.A. and N.P.D. is the sum of the quantities corresponding to that R.A. and N.P.D. as given in the tables (Tables IV. and V.). From the comparisons published in *Monthly Notices*, vol. xlii. pp. 22, 23, vol. xlv. pp. 298–301, and vol. xlv. pp. 366–379, in connection with the comparison of the Argentine General Catalogue and the Cape Catalogue for 1880, forming the first parts of Tables IV. and V., the remaining portions have been formed, and these

tables therefore give the corrections applicable to the Cape Catalogue for 1880, the Melbourne Catalogue for 1870, and the Cape Catalogues for 1860, 1850, and 1840, to reduce them respectively to the system of the Argentine General Catalogue for 1875.

It is remarkable that the differences in R.A. depending on N.P.D. of the Cordoba and Cape 1880 Catalogues at about 130° — 140° are very nearly equal in magnitude, but of *opposite sign*, to those of the Cordoba and Cape 1850 Catalogues at the same N.P.D., the discordances of which at about this place have been the subject of considerable discussion (Introduction to Cape Catalogue for 1850, p. xi., *Monthly Notices*, vol. xlv. p. 38).

I should add that the expenses of the computations, the results of which are embodied in this paper, have been defrayed by a grant from the Government Grant Committee of the Royal Society, to whom my thanks are due.

TABLE I.

N.P.D. R.A. h h	90° — 100°			100° — 110°			110° — 115°		
	$\Delta\alpha$ s	$\Delta\delta$ "	No.	$\Delta\alpha$ s	$\Delta\delta$ "	No.	$\Delta\alpha$ s	$\Delta\delta$ "	No.
0-1	-002	-066	19	+004	+003	14	+015	-044	21
1-2	+003	-034	17	-020	-029	12	+008	-033	18
2-3	+007	-056	23	+040	-032	6	+007	-071	27
3-4	+014	-101	18	+050	-087	6	+017	-074	15
4-5	+026	-069	20	+019	-036	9	+020	-009	13
5-6	+037	-086	45	+069	-065	15	+072	+008	13
6-7	+043	-063	12	+093	-084	19	+079	-030	33
7-8	+090	-107	13	+049	-127	17	+098	-028	26
8-9	+031	-096	13	+090	-122	12	+093	-017	10
9-10	+080	-114	28	+061	-101	11	+002	+055	9
10-11	+030	-072	27	+078	-126	10	+057	+019	7
11-12	+026	-068	15	+036	-071	12	+072	+018	10
12-13	+083	+043	3	-010	-095	2	+073	+011	16
13-14	+070	-091	4	-004	-080	5	+082	+040	9
14-15	+048	-034	4	+048	-024	4	+019	+027	16
15-16	-015	-068	2	-030	-035	5	+043	+023	27
16-17	+010	-016	4	+008	+023	4	+032	+050	23
17-18	-040	-100	3	+017	-185	3	+050	+018	22
18-19	+005	-159	4	000	-072	1	+028	-013	21
19-20	-015	-078	2	-014	+021	5	+075	-020	17
20-21	-020	-048	5	+008	-042	5	+058	-037	18
21-22	+040	-017	3	+005	-036	6	+007	-052	17
22-23	-004	-019	7	+016	-078	10	+018	-076	21
23-24	-029	-023	10	+039	-082	17	+032	-059	19

N.P.D.	115°-120°			120°-125°			125°-130°		
	R.A. h h	$\Delta\alpha$ s	$\Delta\delta$ "	R.A. h h	$\Delta\alpha$ s	$\Delta\delta$ "	R.A. h h	$\Delta\alpha$ s	$\Delta\delta$ "
0-1		+075	-064	28	+100	-103	32	+024	-055
1-2		+077	-045	23	+074	-076	36	+017	-056
2-3		+012	-053	34	+059	-083	40	+023	-043
3-4		+016	-048	41	+047	-055	39	+036	-025
4-5		+017	-032	36	+078	-040	41	+034	-012
5-6		+096	-028	41	+122	-046	50	+088	+017
6-7		+093	-022	76	+128	-026	64	+108	+009
7-8		+108	-008	62	+135	-017	57	+110	+018
8-9		+058	-007	52	+093	-013	62	+094	+012
9-10		+056	-014	59	+082	-025	49	+063	-001
10-11		+017	-007	33	+064	-018	38	+057	-013
11-12		+079	000	45	+095	-029	46	+073	-003
12-13		+086	+008	34	+082	-037	41	+112	-017
13-14		+073	+015	38	+057	-025	46	+111	-030
14-15		+039	+036	53	+083	-010	51	+085	-011
15-16		+028	+014	49	+082	-016	48	+055	-008
16-17		+048	+016	50	+049	-030	70	+061	-033
17-18		-013	-012	49	+040	-027	70	+020	-021
18-19		+025	-024	56	+031	-070	70	+046	-049
19-20		+034	-005	38	+065	-066	37	+020	-038
20-21		+043	-043	51	+067	-108	42	+001	-067
21-22		+028	-068	48	+096	-060	25	+035	-059
22-23		+054	-065	42	+072	-101	27	+027	-053
23-24		+060	-052	34	+052	-065	33	+017	-058
N.P.D.	130°-135°			135°-140°			140°-145°		
	R.A. h h	$\Delta\alpha$ s	$\Delta\delta$ "	R.A. h h	$\Delta\alpha$ s	$\Delta\delta$ "	R.A. h h	$\Delta\alpha$ s	$\Delta\delta$ "
0-1		+037	-046	43	+075	-065	26	+005	-073
1-2		+055	-040	34	+098	-055	30	+043	-086
2-3		+016	-032	42	+061	-081	23	+035	-052
3-4		+033	+006	46	+028	-022	38	+044	-040
4-5		+049	-013	47	+047	-012	30	+041	-038
5-6		+088	+020	50	+066	-045	41	+107	-047
6-7		+084	+049	67	+118	-025	48	+125	-028
7-8		+108	+012	69	+118	-012	64	+139	-027
8-9		+071	-004	76	+106	-024	108	+103	-029
9-10		+059	000	42	+138	-026	64	+131	-050
10-11		+039	+008	55	+095	-045	56	+080	-017
11-12		+061	+015	34	+124	-031	56	+077	-016
12-13		+114	-007	36	+180	-060	44	+159	-049

N.P.D.	130°-135°			135°-140°			140°-145°		
R.A.	$\Delta\alpha$	$\Delta\delta$	No.	$\Delta\alpha$	$\Delta\delta$	No.	$\Delta\alpha$	$\Delta\delta$	No.
h h	s	"		s	"		s	"	
13-14	+ '092	- 0"09	57	+ '137	- 0"62	56	+ '142	- 0"47	55
14-15	+ '119	- 0"22	47	+ '148	- 0"44	54	+ '161	- 0"48	36
15-16	+ '053	- 0"21	70	+ '119	- 0"53	49	+ '134	- 0"39	49
16-17	+ '071	- 0"24	65	+ '088	- 0"63	63	+ '074	- 0"63	52
17-18	+ '047	- 0"24	54	+ '055	- 0"49	79	+ '073	- 0"68	38
18-19	+ '050	- 0"56	54	+ '087	- 0"85	63	+ '109	- 0"65	37
19-20	+ '026	- 0"54	36	+ '108	- 0"69	30	+ '079	- 0"84	39
20-21	+ '048	- 0"68	55	+ '043	- 0"89	32	+ '072	- 0"78	28
21-22	+ '041	- 0"51	28	+ '049	- 1"21	32	+ '028	- 0"82	40
22-23	+ '085	- 0"51	38	+ '038	- 0"81	39	+ '010	- 0"84	44
23-24	+ '053	- 0"51	52	+ '081	- 0"77	31	+ '033	- 0"70	50

N.P.D.	145°-150°			150°-155°			155°-160°		
R.A.	$\Delta\alpha$	$\Delta\delta$	No.	$\Delta\alpha$	$\Delta\delta$	No.	$\Delta\alpha$	$\Delta\delta$	No.
h h	s	"		s	"		s	"	
0-1	- '020	- 0"48	35	+ '039	- 0"24	19	+ '047	- 0"34	15
1-2	+ '001	- 0"45	29	- '029	- 0"34	23	- '026	- 0"23	17
2-3	+ '036	- 0"63	31	+ '098	- 0"26	33	- '024	- 0"02	23
3-4	+ '061	- 0"60	34	+ '080	- 0"33	32	+ '007	- 0"32	23
4-5	+ '039	- 0"32	45	+ '049	- 0"47	35	- '040	- 0"62	25
5-6	- '003	- 0"47	51	- '012	- 0"27	36	- '019	- 0"40	31
6-7	- '045	- 0"37	44	- '018	- 0"03	35	+ '055	- 0"69	27
7-8	+ '020	- 0"76	73	+ '022	- 0"25	31	+ '056	- 0"73	29
8-9	+ '003	- 0"50	60	+ '051	- 0"46	35	+ '020	- 0"59	33
9-10	+ '018	- 0"43	78	+ '013	- 0"38	47	+ '027	- 0"67	34
10-11	- '001	- 0"45	109	- '018	- 0"48	79	+ '008	- 0"44	27
11-12	+ '054	- 0"52	72	+ '017	- 0"33	86	+ '066	- 0"64	28
12-13	+ '041	- 0"46	59	+ '037	- 0"20	44	+ '083	- 0"47	35
13-14	+ '035	- 0"47	48	+ '026	- 0"42	55	+ '066	- 0"52	37
14-15	+ '042	- 0"42	50	+ '026	- 0"46	32	+ '054	- 0"54	32
15-16	- '051	- 0"58	47	+ '017	- 0"30	36	+ '012	- 0"40	26
16-17	- '006	- 0"28	45	- '002	- 0"41	31	+ '072	- 0"45	25
17-18	- '001	- 0"63	45	- '016	- 0"14	32	+ '052	- 0"19	16
18-19	- '074	- 0"78	40	+ '020	- 0"40	35	+ '043	- 0"05	16
19-20	- '005	- 0"48	34	- '057	- 0"40	19	+ '068	- 0"44	32
20-21	- '055	- 0"42	19	+ '008	- 0"55	29	+ '071	- 0"31	18
21-22	- '008	- 0"84	51	+ '010	- 0"50	24	+ '074	- 0"65	9
22-23	- '005	- 0"82	39	+ '039	- 0"43	25	+ '145	- 0"57	11
23-24	- '027	- 0"85	41	+ '008	- 0"34	27	+ '154	- 0"51	17

N.P.D.	160°-165°			165°-170°			170°-180°		
R.A.	$\Delta\alpha$	$\Delta\delta$	No.	$\Delta\alpha$	$\Delta\delta$	No.	$\Delta\alpha$	$\Delta\delta$	No.
h h	s	"		s	"		s	"	
0-1	+ '041	- 0'25	22	- '068	- 0'97	25	- '169	- 0'29	13
1-2	- '078	- 0'35	18	- '023	- 0'73	23	- '064	- 0'32	17
2-3	+ '078	- 0'07	16	+ '184	- 0'67	16	+ '105	- 0'13	11
3-4	+ '034	+ 0'09	20	- '030	- 0'62	21	- '011	+ 0'34	15
4-5	+ '004	- 0'33	16	- '102	- 0'52	14	- '337	- 0'12	11
5-6	- '022	- 0'35	20	- '067	- 0'86	15	- '222	- 0'70	9
6-7	+ '048	- 0'66	20	- '109	- 0'64	14	- '261	- 0'90	11
7-8	+ '067	- 0'74	22	- '050	- 1'34	15	- '171	- 0'96	11
8-9	+ '060	- 0'50	28	- '090	- 1'26	23	- '280	- 1'44	7
9-10	'000	- 0'69	22	- '076	- 1'90	19	- '066	- 0'75	20
10-11	- '033	- 0'52	19	- '066	- 1'13	18	- '161	- 0'87	19
11-12	+ '123	- 0'32	27	+ '027	- 1'42	17	- '269	- 0'57	11
12-13	+ '074	- 0'44	24	+ '098	- 1'12	13	- '061	- 0'87	11
13-14	+ '056	- 0'64	17	+ '003	- 0'86	12	- '103	- 0'98	10
14-15	- '041	- 0'54	20	- '048	- 1'25	20	- '038	- 0'87	11
15-16	- '043	+ 0'19	27	+ '002	- 0'77	19	- '525	+ 0'43	2
16-17	+ '032	+ 0'01	20	+ '106	- 0'90	16	+ '060	+ 0'14	10
17-18	+ '005	0'00	16	+ '010	- 0'79	14	+ '043	- 0'32	12
18-19	+ '080	+ 0'10	18	+ '055	- 0'88	11	+ '100	- 0'74	12
19-20	- '063	- 0'42	26	- '079	- 1'01	16	- '163	- 0'33	3
20-21	+ '056	- 0'11	25	- '102	- 0'62	25	- '044	- 0'15	17
21-22	- '011	- 0'24	26	- '047	- 1'16	16	- '151	+ 0'11	17
22-23	+ '024	- 0'20	15	- '105	- 0'98	17	- '092	- 0'47	11
23-24	+ '070	- 0'56	20	+ '006	- 0'51	8	- '266	- 0'51	19

TABLE II.

R.A.	$\Delta\alpha$	$\Delta\delta$	Number of Stars.
h h	s	"	
0-1	+ 0'020	- 0'56	404
1-2	'020	'52	382
2-3	'042	'48	411
3-4	'032	'35	436
4-5	'022	'31	448
5-6	'051	'34	526
6-7	'069	'21	589
7-8	'088	'23	663
8-9	'065	'30	680
9-10	'057	'42	600
10-11	'024	'36	615

R.A. h h	$\Delta\alpha$ s	$\Delta\delta$ "	Number of Stars.
11-12	·061	·31	557
12-13	+0·098	-0·37	440
13-14	·076	·37	491
14-15	·068	·29	473
15-16	·043	·23	519
16-17	·053	·29	528
17-18	·029	·33	529
18-19	·042	·54	500
19-20	·028	·49	385
20-21	·027	·59	403
21-22	·016	·66	381
22-23	·028	·68	381
23-24	+0·025	-0·61	411
0-24	+0·047	-0·40	11752

TABLE III.

N.P.D.	$\Delta\alpha$ s	$\Delta\alpha \sin N.P.D.$ s	$\Delta\delta$ "	Number of Stars.
90-100	+0·028	+0·028	-0·73	301
100-110	·038	·037	·70	210
110-115	·044	·041	·17	428
115-120	·051	·045	·19	1072
120-125	·077	·065	·43	1114
125-130	·058	·046	·20	1199
130-135	·064	·047	·17	1197
135-140	·097	·066	·49	1156
140-145	·088	·054	·49	1229
145-150	·006	·003	·54	1179
150-155	·017	·008	·36	880
155-160	·041	·016	·47	586
160-165	+·024	+·007	·32	504
165-170	-·030	-·006	·97	407
170-180	-0·113	-0·010	-0·47	290
90-180	+0·047	+0·036	-0·40	11752

TABLE IV.

R.A. h	Cape, 1820.			Melbourne, 1870.			Cape, 1860.			Cape, 1850.			Cape, 1840.		
	$\Delta\alpha$ s	$\Delta\delta$ "	$\Delta\delta$ "	$\Delta\alpha$ s	$\Delta\delta$ "	$\Delta\delta$ "	$\Delta\alpha$ s	$\Delta\delta$ "	$\Delta\delta$ "	$\Delta\alpha$ s	$\Delta\delta$ "	$\Delta\delta$ "	$\Delta\alpha$ s	$\Delta\delta$ "	$\Delta\delta$ "
0 0	-0 024	-0 19		+0 009	+0 04		+0 016	-0 12		+0 031	-0 07		+0 097	-0 44	
1 0	0 27	14		+0 001	-0 2		+0 012	23		0 23	14		119	27	
2 0	0 16	10		-0 020	+0 4		-0 003	35		0 26	25		126	18	
3 0	0 10	-0 2		0 53	21		0 19	17		+0 011	22		0 89	17	
4 0	0 20	+0 7		0 65	34		0 24	16		-0 018	19		+0 021	28	
5 0	-0 10	0 7		-0 027	30		0 05	26		0 24	24		-0 003	48	
6 0	+0 13	12		+0 007	18		0 08	22		-0 015	22		0 002	55	
7 0	0 32	15		+0 008	10		0 15	13		+0 005	18		+0 007	54	
8 0	0 30	11		-0 016	12		0 12	+0 3		+0 005	18		-0 030	46	
9 0	+0 14	04		0 33	+13		0 14	-0 3		-0 008	21		0 85	29	
10 0	-0 06	01		0 41	-0 9		0 57	11		0 28	17		125	10	
11 0	-0 04	06		-0 019	26		-0 070	16		0 37	-0 6		124	+0 9	
12 0	+0 33	06		+0 036	34		+0 008	27		0 13	+0 1		0 67	19	
13 0	0 40	03		0 57	39		0 52	30		0 17	0 6		0 48	13	
14 0	0 25	07		0 48	19		0 50	-0 5		0 47	17		0 72	32	
15 0	0 09	14		0 45	-0 1		0 50	+0 7		0 49	27		0 67	60	
16 0	+0 01	14		0 43	+0 1		+0 041	14		0 34	30		0 43	76	
17 0	-0 06	+0 9		+0 023	+0 1		-0 002	19		0 19	27		0 27	69	
18 0	0 11	-0 4		-0 001	-0 10		0 34	14		-0 007	18		0 26	44	
19 0	0 12	12		0 12	11		-0 023	18		+0 011	13		0 10	39	
20 0	0 19	14		0 17	04		0 00	20		0 21	16		-0 002	42	
21 0	0 25	23		-0 006	07		+0 008	+0 2		0 31	12		+0 010	39	
22 0	0 25	27		+0 007	-0 7		0 02	-0 18		0 37	11		0 25	09	
23 0	-0 020	-0 25		+0 011	0 00		+0 008	-0 20		+0 039	+0 02		+0 063	-0 40	

TABLE V.

N.P.D. °	Cape, 1883.		Melbourne, 1870.		Cape, 1860.		Cape, 1850.		Cape, 1840.	
	$\Delta\alpha$ s	$\Delta\delta$ "	$\Delta\alpha$ s	$\Delta\delta$ "	$\Delta\alpha$ s	$\Delta\delta$ "	$\Delta\alpha$ s	$\Delta\delta$ "	$\Delta\alpha$ s	$\Delta\delta$ "
95	+ 0.028	- 0.73	+ 0.023	- 0.57	+ 0.034	- 0.82	+ 0.015	- 0.19	- 0.008	- 0.73
100	.032	.71	.018	.36	.028	.53	.011	.28	.018	.53
105	.038	.70	.013	— .21	.012	.46	+ .006	— .35	.015	— .16
110	.041	.37	.004	+ .07	.003	.30	— .007	+ .17	.011	+ .37
115	.048	.19	.010	+ .11	.015	.40	.022	.37	.011	.41
120	.064	.32	.028	— .13	.040	.65	.027	+ .07	.007	.11
125	.065	.32	.040	— .17	.063	.60	.048	— .12	.016	.07
130	.060	.20	.046	+ .10	.080	.37	.074	— .07	.027	.30
135	.078	.32	.052	.18	.098	.43	.071	+ .01	.010	.46
140	.088	.50	.055	.02	.118	.63	.073	.04	.006	.48
145	.048	.53	.035	.01	.103	.67	.055	.16	+ .012	.78
150	.010	.47	.005	.17	.064	.53	.068	+ .08	.000	.92
155	.029	.42	+ .005	.31	.067	.32	.031	— .04	+ .047	.81
160	+ .032	.44	— .037	.40	+ .013	.15	.010	.00	+ 0.083	+ .44
165	— .007	.80	.090	+ .13	— 0.078	— 0.33	— 0.032	— .23	—	— .31
170	.058	.83	.125	.00	—	—	—	— 0.09	—	— 0.19
175	— 0.113	— 0.47	— 0.176	+ 0.13	—	—	—	—	—	—

Blackheath : Jan., 1887.

*A Catalogue of 480 Stars to be used as Fundamental Stars for
Observations of Zones between 20° and 80° South Declination.
By Prof. A. Auwers.*

One of the most important works to be done by the next generation of astronomers will consist in a new and systematic determination of the places of the southern fixed stars down to the 9th magnitude.

One object of this determination will be the completion of the general knowledge of stellar proper motions by comparisons to be made with Dr. Gould's determinations for the epoch 1875. If this alone were considered, the new observations might advantageously be deferred some ten or twenty years more. But the wants of the great photographic survey, to be made according to the Paris programme with a mean epoch of probably $1900 \pm$, will render it preferable to have this new determination made nearly for this same epoch.

The most efficient way to secure homogeneousness and completeness in this determination will be the arrangement of zone-observations like those of the *Astronomische Gesellschaft*, till now made between the declinations 80° and -2° , and presently to be extended to -23° , constructing the working lists for the zones from the preliminary photographic survey of the southern heavens by which Dr. Gill has undertaken to complete the *Bonner Durchmusterung*. Astronomers hope to have the results of this survey within the next few years, and in order to enable the southern observatories then not only to begin the zone-observations without delay, but also to make the reductions within due time, it appears not too early to prepare for these observations of southern zones by providing at once for a uniform and accurate determination of the positions of a sufficient number of stars, which ought to be used as fundamental stars in the reduction of the zones.

Dr. Gill having expressed to me his desire that I should make the selection of these stars, in order that they should be included in the new working list which was to be constructed about a year ago for the Transit circle of the Cape Observatory, I have drawn up the following list, which I now beg herewith to communicate to the astronomers of the southern hemisphere, expressing, in accordance with Dr. Gill, the wish that a sufficient number of them will co-operate towards the accurate determination of these stars in the same manner as has been done for the fundamental stars used in the zone-observations of the *Astronomische Gesellschaft*.

The selection of the stars included in the following catalogue was to be made upon the following principles:—

1. The stars ought to be distributed, at convenient intervals, as equally as possible over the area covered by the zones to be observed. This area may be considered to be conveniently

filled with fundamental stars, if in each single zone comprising 10° of declination these stars follow each other on the average within 15^m to 20^m in the lower declinations, and 20^m to 25^m in the higher.

2. The stars ought to be of such a kind as will afford the most complete guaranty for accurate and accordant observation by different observers. The following stars should be avoided:—first, very bright stars, with whose observations rather large personalities are known occasionally to interfere; and second, double stars in which the companion might disturb the observation of the principal star, or possibly prevent its being referred by different observers to exactly the same point.

3. Where there is any choice no star ought to be admitted unless it be sufficiently observed in previous catalogues to allow of a determination of its proper motion, with an accuracy sufficient to allow the new position to be brought forward ten or fifteen years without diminishing its accuracy to an extent which would become appreciable in the reduction of the zone-observations.

The most elegant solution of the problem with respect to condition 1, and apparently also to condition 2, might have been attained by the exclusive use of the stars of one or two middle orders of magnitude, the stars of about 6 mag. and 7 mag., as fundamental stars for the zones. The number of these stars is sufficiently great in all regions to allow of a very uniform distribution of the fundamental points throughout, and, at the same time, the stars of 6 mag. and 7 mag. most probably are those objects which with the present meridian instruments are observed with the highest degree of precision in the single observation and with the least amount of systematic difference between different observers. But in the latter respect the apparent gain to be obtained by their use would be quite illusory, because the places of these stars themselves must be determined by referring them to the brighter stars, so that it remains impossible to get rid of any kind of personality to which the observations of brighter stars are liable. On the other hand, with the stars of 6 mag. and 7 mag., condition 3 could be fulfilled only in such an incomplete and unsatisfactory manner that their choice could not be recommended. The sacrifice of uniformity of distribution unavoidably connected with the choice of the stars of brighter magnitudes than the 6th, because of their varying frequency and comparatively small number, is really much the lesser evil.

Having, by condition 1, fixed the extent of the catalogue at a number of stars between 400 and 500, I have for the above reasons chosen those stars to form its main body whose magnitude, according to Gould's *Uranometry*, ranges between the limits 2.0 and 5.0 . The limits of the zones, for which the fundamental stars were to be selected, were determined by the southern limit of the zones of the *Astronomische Gesellschaft* and the northern limit of the special circumpolar work already under-

taken by the Cape Observatory, and therefore will be -23° and -80° declination. For the fundamental catalogue I have extended the northern limit to -20° , but generally retained the southern limit of -80° , because it does not seem desirable to combine the presently proposed observations with those of a greater number of stars within ten degrees of the South Pole. The latter work may be better made the object of other specially conducted observations besides those of the Cape Observatory already mentioned.

The Uranometria Argentina contains between declinations -20° and -80° (for the Equinox 1875) 380 stars not brighter than 2.0 mag. and not fainter than 5.0 mag., which are without companions such as might interfere with the accurate and uniform observation of the principal star, one or two variable stars, however, being included in this number, which during a part of their period fall somewhat below 5 mag. The exclusion of double stars has been adhered to with still greater rigidity than in the construction of the fundamental list for the southern zones (-2° to -23°) of the Astronomische Gesellschaft; even the stars with very faint or distant companions have been excluded with rare exceptions. For even where such companions cannot, by their faintness or their relative position, influence in any degree the proper estimate of the point to be observed, or of its correct position with respect to the wires, an observer—and more possibly a good observer—is liable to be troubled to a certain extent by their mere existence, as they are apt to detract, for a moment, part of the attention from what ought to constitute during the transit of a fundamental star the exclusive object of the full attention of the astronomer observing a zone—viz. that he shall fix, with the greatest possible accuracy, a point to which to refer the zone under observation. Only in some very few cases I have retained some of those known double stars, in which the possibility of a disturbing influence appears limited to a very small extent—wholly excluded in one case—viz. four objects (to which afterwards *ε Canis maj.* has been added as a fifth) already occurring in the Fundamental Catalogue of the Berliner Jahrbuch, and five more, which could not easily be superseded for want of other stars in the same region. Possibly some more objects of this kind will be found in the catalogue when the stars of the southern heavens have been examined more closely with regard to their duplicity than has yet been done, or reported to have been done.

Out of the 380 stars accordingly available, including the nine known double stars, it was not possible to retain for the catalogue more than 280. The remaining 100 were excluded, part of them being wholly superfluous in regions covered densely enough without them; part of them because their transits would take place so nearly at the same time with those of *several* other stars in remoter declinations that, by retaining them, the time necessary for complete observation of the catalogue would have been

disproportionally extended. The majority of these excluded stars is contained in the hours 6 to 9 and 12 to 15 of Right Ascension, in which the brighter stars are most densely crowded together in the southern heavens. To replace these stars in more convenient positions, where it appeared at all necessary to replace them, and to fill up the greater gaps, chiefly in the hours 19 to 2, between the brighter stars, I had recourse to the stars noted 5.1 mag. to 6.0 mag. in the Uranometria Argentina, in some cases, for want of such stars, to still fainter ones, adding in this manner 193 stars between the limits -20° and -80° , sixteen of which are of the magnitude 6-7, and the four faintest of the magnitude 7-6; finally, two stars somewhat exceeding the upper limit of brightness (ϵ *Canis maj.* and β *Crucis*) were added, and, besides, five stars situated a little beyond the southern limit of -80° , in regions which could not be provided for sufficiently without them.

The catalogue accordingly contains 480 stars, which are distributed for the Equinox 1875 as follows:—

Hour	contains	Hour	contains	Hour	contains
0	19 stars	8	17 stars	16	23 stars
1	19 "	9	19 "	17	23 "
2	18 "	10	19 "	18	25 "
3	19 "	11	19 "	19	21 "
4	15 "	12	21 "	20	19 "
5	22 "	13	20 "	21	18 "
6	19 "	14	19 "	22	26 "
7	21 "	15	16 "	23	23 "

Zone -20° to -30° contains 99 stars

"	-30°	"	-40°	"	85	"
"	-40°	"	-50°	"	89	"
"	-50°	"	-60°	"	77	"
"	-60°	"	-70°	"	70	"
"	-70°	"	-80°	"	54	"
"	-80°	"	-82.5°	"	6	"

This distribution may be considered to be sufficiently uniform, and cannot be rendered more uniform, if conditions 2 and 3 remain fulfilled with equal approximation throughout. It has not been possible, with the available material, to reach the average number of twenty stars in each single hour of Right Ascension, while in some hours it was possible somewhat to exceed this number without interfering with an equable facility of getting through the catalogue in the observations to be made for the determination of the fundamental positions. The selection of the stars has been assisted throughout by laying down their positions, and those of a good many other stars of 5 mag. and 6 mag., besides those finally selected, in a map drawn upon a large

scale, carefully scrutinising in every single instance what combination would afford the greatest advantage in the observations and the reduction of the zones. As to the determination of the fundamental stars, care was taken that, assuming five minutes to be required for a complete observation with a transit circle, in no Right Ascension should more stars interfere with each other than would allow of the whole catalogue being gone through n times completely in $4n$ observing nights. This scrutiny, however, was made with the catalogue drawn up for the year 1875, and has not been repeated with the Right Ascensions as finally brought forward to the epoch 1900.

In what degree it has been found possible to adhere to condition 3, regarding the means for determining the proper motions, may be inferred from the following statement. Of the 480 stars there occur—

In the Catalogue of Lacaille (princ. st.)	...	133
" " Bradley...	...	84
" " Piazzì ...	...	221
" " Johnson (St. Helena) ...	...	252
" Cape Catalogue for 1840	...	410
" " " 1850	...	452
" " " 1860	...	248
" " " 1880	...	463
" Williamstown Catalogue	...	127
" First Melbourne Catalogue	...	244

all of them, of course, being included in Gould's Catalogue (*Catalogo General Argentino*).

Five stars were inserted into the catalogue which are not contained in any previous catalogue except Gould's (three of them, however, forming part of the list of fundamental stars recently determined for the southern zones of the *Astronomische Gesellschaft*), and four others, which besides in this catalogue occur either in Stone's Catalogue, 1880, or in the Melbourne Catalogue. Two stars have been observed, previously to Gould and Stone 1880, only by Piazzì. Further, fourteen stars do not occur previously to the Cape Catalogue for 1850 (except Taylor's Catalogue, which contains some of them, but scarcely affords positions fit for determining proper motions), and the Cape 1850 Catalogue gives only one co-ordinate for three of these stars. Altogether, therefore, for twenty-five stars condition 3 is only very unsatisfactorily fulfilled; but in all these cases it proved to be impossible to replace the stars at convenient places by other stars already better determined.

The magnitudes are given in the following catalogue according to the determinations in the *Uranometria Argentina*. The designation of the stars is, for the great majority of them, likewise that of the same work. In those constellations,

however, which are visible in middle Europe completely, or at least to a predominant part of their full extent, and which are comprised so far in the uranometrical researches of Bayer and Argelander, or in Flamsteed's catalogue work, Bayer-Argelander's nomenclature and Flamsteed's numbering, together with limits of the constellations drawn accordingly, ought to be retained, in my opinion, without any alterations (except those, of course, which are necessary to correct for accidental errors). From those constellations, small parts of which only can be seen in middle Europe and are investigated by Bayer and his European successors, *Argo*, *Centaurus*, *Lupus*, *Corona Australis*, Bayer's letters ought to be withdrawn, being only apt to interfere with the correct extension of his own principle of lettering over the whole constellation. In *Argo*, however, I do not agree with Gould completely. It seems to me impossible to supersede designations so thoroughly connected with the history of astronomy as α *Argus* or η *Argus* by other designations, and I consider it necessary, therefore, to retain the name of the entire constellation *Argo* in the designation of its brighter stars. The limit for distinguishing between this entire constellation and its separate parts will be drawn in the most simple way, if all the stars designated with Lacaille's Greek letters are counted through *Argo*, and the subdivisions *Carina*, *Puppis*, and *Vela* are introduced only to distinguish between the smaller stars designated by a threefold repetition of the Latin alphabet. According to this principle the names are set down in the catalogue, with one more trifling deviation from the *Uranometria Argentina*. In this work two stars in *Puppis* are lettered I and J, a similarity of designation too much apt to produce confusion, and better therefore to be avoided. I have suppressed the symbol J and inserted the star which has it appended in the *Uranometria Argentina* simply as *Puppis* 218 Gould.

The last column contains some remarks to note the few double stars, and to call the attention to neighbouring stars in such cases when they might give rise to mistakes. Those remarks would not appear to be needed in the determination of the positions of the stars of the catalogue with meridian instruments; but it might be inferred from experience that they will prove to be useful in the zone-observations themselves or in some other use of the present catalogue—for example, in field-work.

Catalogue.

No.	Name.	Mag.	R.A. 1900.	Ann. var.	Decl. 1900.	Ann. var.	Remarks.
1	ϵ Phœnicis	4	^h ^m ^s O 4 20	^s + 3.1	-46° 17.9	+ 0.33	
2	κ^2 Sculptoris	5-6	6 30	3.0	28 21.4	0.33	
3	θ Sculptoris	5-6	6 38	3.0	35 41.7	0.33	
4	ζ Tucanæ	4	14 51	+ 3.2	65 27.8	+ 0.35	

No.	Name.	Mag.	R.A. 1900.			Ann. var.	Decl. 1900.			Ann. var.	Remarks.
			h	m	s		°	'	"		
5	β Hydri	3-2	0	20	30	+3'3	-77	49'1	+0'34		
6	α Phœnicis	2-3		21	19	2'9	42	50'9	0'33		
7	Ceti, 49 G.	5-6		25	23	3'0	24	20'4	0'33		
8	λ^1 Phœnicis	5-4		26	35	2'9	49	21'4	0'33		
9	Sculptoris, 77 G.	6		28	44	3'0	30	6'6	0'33		
10	Phœnicis, 58 G.	6-5		29	43	2'9	52	55'5	0'33		
11	Ceti, 59 G.	6		32	12	3'1	25	19'1	0'33		
12	μ Phœnicis	5-4		36	36	2'8	46	38'0	0'33		
13	η Phœnicis	4-5		38	52	2'7	58	0'7	0'33		
14	λ^2 Sculptoris	6		39	21	2'9	38	58'4	0'33		
15	Ceti, 73 G.	5-6		39	47	3'0	22	33'4	0'33		
16	λ Hydri	6-5		45	7	2'1	75	28'0	0'33		
17	λ^2 Tucanæ	5-6		51	16	2'3	70	4'0	0'33		
18	α Sculptoris	4		53	47	2'9	29	53'9	0'32		
19	Phœnicis, 80 G.	6-7		57	48	2'5	57	32'4	0'32		
20	β Phœnicis	3-4	1	1	37	2'7	47	15'3	0'32		
21	ι Tucanæ	6-5		3	20	2'4	62	18'6	0'32		
22	Sculptoris, 102 G.	6		8	9	2'8	38	23'2	0'32		
23	Sculptoris, 109 G.	6		18	52	2'8	31	27'9	0'31		
24	Hydri, 9 G.	6-7		21	38	2'1	64	53'4	0'31		
25	γ Phœnicis	3-4		24	1	2'6	43	49'8	0'31		
26	48 Ceti	5-6		24	48	2'9	22	8'8	0'31		
27	δ Phœnicis	4		27	5	2'5	49	35'7	0'31		
28	Hydri, 14 G.	6-7		32	59	0'3	79	0'7	0'30		
29	Sculptoris, 129 G.	6		37	38	2'6	37	20'2	0'30		
30	ϵ Sculptoris	5		40	57	+2'8	25	33'1	0'30		9 mag. 5"
31	τ^1 Hydri	6-7		41	16	-0'1	79	39'2	0'30		
32	ζ^2 Eridani	5-6		42	17	+2'3	54	1'6	0'30		
33	ψ Phœnicis	5		49	38	2'4	46	47'6	0'29		
34	χ Eridani	4		52	4	2'3	52	6'4	0'30		
35	η^2 Hydri	5		52	24	1'5	68	8'4	0'30		
36	59 ν Ceti	4		55	17	2'8	21	33'7	0'29		
37	α Hydri	3		55	37	1'9	62	3'4	0'29		
38	ν Fornacis	5	2	0	0	2'7	29	46'6	0'29		
39	μ Fornacis	5		8	30	2'6	31	11'5	0'28		
40	Phœnicis, 135 G.	6		10	29	2'4	41	37'9	0'28		
41	ϕ Eridani	3-4		12	55	2'1	51	58'5	0'28		
42	κ Fornacis	5		17	57	+2'7	24	16'2	+0'28		

No.	Name.	Mag.	R.A. 1900.			Ann. var.	Decl. 1900.			Ann. var.	Remarks.
			h	m	s		°	'	''		
43	δ Hydri	4	2	19	58	+1'1	69	6'9	+0'27		
44	λ Horologii	6		22	6	1'7	60	45'5	0'27		
45	κ Hydri	6		22	16	0'3	74	5'9	0'27		
46	κ Eridani	4		23	19	2'2	48	10'1	0'27		
47	λ ¹ Fornacis	6		28	56	+2'5	35	5'3	0'27		
48	μ Hydri	6-5		33	46	-1'5	79	32'7	0'26		
49	η Horologii	6-5		34	6	+2'0	52	58'6	0'26		
50	ι Eridani	4		36	43	2'4	40	17'0	0'26		
51	ε Hydri	4		38	2	0'9	68	41'8	0'26		
52	β Fornacis	4-5		44	55	2'5	32	49'6	0'25		
53	2 τ ² Eridani	5-4		46	30	2'7	21	25'0	0'25		
54	β Horologii	5		56	54	1'1	64	28'1	0'24		
55	11 τ ³ Eridani	4		57	59	2'6	24	0'9	0'24		
56	Eridani, 58 G.	6-7		59	31	2'0	47	22'0	0'24		
57	μ Horologii	5-6	3	1	15	1'4	60	7'5	0'23		
58	θ Hydri	6		2	3	0'1	72	17'6	0'23		
59	12 Eridani	3-4		7	48	2'5	29	22'9	0'24		7-8 mag. 9"
60	Horologii, 38 G.	6-7		10	1	1'5	57	41'7	0'23		
61	Fornacis, 79 G.	7-6		10	44	2'4	35	55'8	0'23		
62	ε Eridani	4-5		15	55	+2'4	43	27'1	0'23		
63	ι Hydri	6		18	26	-1'6	77	45'2	0'22		
64	κ Reticuli	5		27	36	+1'0	63	17'5	0'21		
65	19 τ ³ Eridani	4		29	22	2'6	21	58'1'	0'20		
66	Horologii, 45 G.	6		29	35	1'8	50	43'1	0'20		
67	γ Eridani	5		33	30	2'1	40	36'1	0'20		
68	δ Fornacis	5		38	16	2'4	32	15'4	0'19		
69	27 τ ⁶ Eridani	4		42	32	2'6	23	32'7	0'18		
70	β Reticuli	4		42	56	0'7	65	7'3	0'19		
71	γ Eridani	4		45	43	+2'2	36	30'2	0'18		
72	γ Hydri	3		48	47	-1'0	74	32'7	0'18		
73	Doradus, 1 G.	7-6		51	56	+1'6	52	58'9	0'18		
74	36 τ ⁹ Eridani	4		55	40	2'5	24	18'0	0'17		
75	δ Reticuli	5-4		57	9	0'9	61	41'0	0'17		
76	Eridani, 174 G.	6	4	1	29	2'5	27	55'7	0'17		
77	α Horologii	4		10	41	2'0	42	32'5	0'15		
78	α Reticuli	3-4		13	8	0'8	62	43'4	0'15		
79	γ Doradus	4-5		13	24	1'6	51	44'4	0'15		
80	Eridani, 212 G.	5-6		16	17	+2'6	20	52'7	+0'15		

No.	Name.	Mag.	R.A. 1900.			Ann. var.	Decl. 1900.		Ann. var.	Remarks.
			h	m	s		°	'		
81	43 δ Eridani	4	4	20	16	+2.2	34	15.0	+0.14	
82	η Reticuli	6		20	47	+0.6	63	37.5	0.14	
83	δ Mensæ	6		24	43	-4.2	80	27.0	0.13	
84	δ Cæli	5		27	47	+1.8	45	10.1	0.13	
85	52 ν^2 Eridani	4-3		31	40	2.3	30	46.0	0.13	
86	α Doradus	3		31	50	1.3	55	15.1	0.13	
87	Eridani, 258 G.	6		35	57	2.5	24	40.7	0.12	
88	α Cæli	5-4		37	20	1.9	42	3.3	0.12	
89	κ Doradus	6-5		42	50	+0.9	59	55.0	0.11	
90	μ Mensæ	6-5		44	3	-0.6	71	6.9	0.11	
91	2 ϵ Leporis	3-4	5	1	13	+2.5	22	30.3	0.08	
92	η^2 Pictoris	5-6		2	22	1.5	49	42.8	0.08	
93	ζ Doradus	5		3	48	+1.0	57	36.7	0.07	
94	β Mensæ	6-5		4	19	-0.8	71	27.1	0.08	
95	ξ Mensæ	6		10	14	-7.0	82	36.3	0.07	
96	θ Doradus	5		13	50	-0.1	67	17.8	0.07	
97	$\circ$ Columbæ	5		13	51	+2.1	34	59.4	0.07	
98	Columbæ, 12 G.	6		15	26	2.4	27	28.3	0.06	
99	ζ Pictoris	6		16	55	1.5	50	42.9	0.06	
100	Columbæ, 18 G.	6		23	53	1.9	41	1.3	0.05	
101	Pictoris, 20 G.	6-5		27	24	1.6	47	9.0	0.04	
102	ϵ Columbæ	4		27	39	2.1	35	32.6	0.05	
103	β Doradus	4		32	46	+0.5	62	33.3	0.04	
104	γ Mensæ	6-5		35	50	-2.4	76	24.9	0.03	
105	α Columbæ	2-3		36	1	+2.2	34	7.6	0.03	
106	13 γ Leporis	4		40	18	2.5	22	28.7	0.03	7-8 mag. pr.1 ^a b.1.6
107	δ Doradus	4-5		44	35	0.1	65	46.4	0.02	
108	15 δ Leporis	4		47	0	2.6	20	53.1	0.01	
109	β Columbæ	3		47	26	2.1	35	48.4	0.03	
110	γ Pictoris	5-4		48	0	1.1	56	11.5	0.02	
111	η Columbæ	4		56	5	+1.8	42	49.2	+0.01	
112	κ Mensæ	6		57	2	-4.1	79	22.8	0.00	
113	Puppis, 1 G.	6	6	1	36	+1.7	45	2.2	0.00	6-7 mag. seq. 12 ^a a.2.5
114	Columbæ, 74 G.	6		2	15	2.3	29	44.8	0.00	
115	Pictoris, 47 G.	6-5		6	8	0.5	62	8.1	-0.01	
116	δ Pictoris	5		8	21	1.2	54	56.8	0.01	
117	κ Columbæ	5		12	59	+2.1	35	6.4	0.02	
118	α Mensæ	5-6		13	13	-1.8	74	43.0	-0.02	

No.	Name.	Mag.	R.A. 1900.			Ann. var.	Decl. 1900.			Ann. var.	Remarks.
			^h	^m	^s	^s	[°]	[']	^{''}		
119	1 ζ Canis maj.	3	6	16	28	+2.3	-30	1'2	-0'02		
120	λ Canis maj.	6-5		24	27	+2.2	32	31.0	0.03		
121	π^2 Doradus	6		26	20	-0.5	69	38.0	0.04		
122	5 ξ^2 Canis maj.	5		30	52	+2.5	22	53.1	0.04		
123	ν Carinae	5		32	46	1.3	52	53.5	0.05		
124	ν Argus	3-4		34	42	1.8	43	6.4	0.05		
125	13 κ Canis maj.	4		46	6	2.2	32	23.5	0.06		
126	α Pictoris	3-4		47	10	0.6	61	50.1	0.06		
127	τ Argus	3		47	27	+1.5	50	29.7	0.07		
128	ζ Mensae	6		48	23	-4.9	80	42.5	0.07		
129	ι Volantis	6-5		52	35	-0.7	70	50.3	0.08		
130	Canis maj., 105 G.	6		54	30	+2.5	25	16.8	0.08		10-11 mag. 8"
131	ϵ Canis maj.	2-1		54	42	2.4	28	50.1	0.08		
132	Carinae, 27 G.	6-5	7	2	26	+1.1	56	35.8	0.09		
133	θ Mensae	6-5		2	55	-3.7	79	16.6	0.09		
134	25 δ Canis maj.	2		4	20	+2.4	26	14.0	0.09		
135	I Puppis	5		9	43	1.7	46	35.6	0.10		
136	π Argus	3-2		13	37	2.1	36	55.1	0.10		
137	29 Canis maj.	5-6		14	30	2.5	24	22.5	0.10		
138	δ Volantis	4		16	53	0.0	67	46.4	0.11		
139	31 η Canis maj.	3-2		20	8	2.4	29	6.4	0.11		
140	Puppis, 108 G.	5-6		29	46	2.6	22	4.8	0.13		
141	Q Carinae	5-6		33	11	1.5	52	18.6	0.13		
142	f Puppis	5		33	40	2.2	34	44.6	0.13		
143	l Puppis	4-5		39	47	2.4	28	42.9	0.14		
144	c Puppis	4-3		41	41	+2.1	37	43.5	0.14		
145	ζ Volantis	4-5		43	4	-0.7	72	21.9	0.14		
146	7 ξ Argus	4-3		45	5	+2.5	24	36.5	0.15		
147	P Puppis	4-5		46	12	1.8	46	7.2	0.15		
148	a Puppis	4		48	46	2.1	40	19.1	0.15		
149	Volantis, 19 G.	6		49	1	0.4	65	56.4	0.15		
150	Puppis, 218 G.	4-5		50	22	1.8	47	50.5	0.15		
151	χ Argus	4-3		54	14	1.5	52	42.8	0.16		
152	ζ Argus	2-3	8	0	5	2.1	39	43.3	0.17		
153	ρ Argus	3		3	17	2.5	24	0.9	0.17		
154	γ Argus	3		6	27	1.8	47	2.5	0.17		
155	q Puppis	5-4		14	49	2.2	36	21.0	0.18		
156	ϵ Argus	2		20	28	+1.2	59	11.3	-0.19		

No.	Name.	Mag.	R.A. 1900.	Ann. var.	Decl. 1900.	Ann. var.	Remarks.
			^h ^m ^s	^s	[°] [']	[°] [']	
157	θ Chamæleontis	5-4	8 23 39	-1'7	-77 9'7	-0'20	
158	β Volantis	4	24 39	+0'7	65 48'1	0'20	
159	ϵ Velorum	5-4	34 8	2'1	42 38'4	0'21	
160	Pyxidis, 19 G.	6-5	34 46	2'6	22 19'4	0'21	
161	β Pyxidis	4-5	36 12	2'3	34 57'1	0'21	
162	δ Carinæ	5-4	38 24	1'3	59 24'2	0'21	
163	α Pyxidis	4	39 34	2'4	32 49'5	0'21	
164	δ Argus	2	41 56	1'7	54 20'5	0'22	
165	α Velorum	4	42 38	+2'0	45 40'5	0'22	
166	η Chamæleontis	6-5	44 44	-1'9	78 36'0	0'22	
167	γ Pyxidis	4-5	46 18	+2'5	27 20'3	0'22	
168	ϵ Carinæ	4	52 47	1'4	60 15'8	0'23	
169	ϵ Velorum	5-4	9 0 42	2'1	46 41'9	0'24	
170	α Volantis	4	0 52	1'0	65 59'7	0'24	
171	λ Argus	2-3	4 19	2'2	43 1'7	0'24	
172	G Carinæ	5	4 53	0'2	72 12'0	0'24	
173	β Argus	2	12 6	0'7	69 18'3	0'25	
174	ι Argus	2-3	14 25	1'6	58 51'3	0'25	
175	θ Pyxidis	5-6	17 4	2'6	25 32'4	0'25	
176	κ Argus	3-2	19 1	1'9	54 35'0	0'25	
177	ϵ Antliæ	5	25 7	2'5	35 30'8	0'26	
178	ψ Argus	4-3	26 46	2'4	40 1'7	0'26	
179	Hydræ, 160 G.	6	28 36	2'8	20 40'4	0'26	
180	H Carinæ	6	30 51	0'5	72 38'2	0'26	
181	h Carinæ	5	31 32	1'7	58 47'1	0'27	
182	M Velorum	5	33 15	2'1	48 54'4	0'27	
183	θ Antliæ	5	39 45	2'7	27 18'7	0'27	
184	l Carinæ	4-5	42 30	1'6	62 2'8	0'27	
185	m Velorum	5	47 49	2'3	46 4'7	0'28	
186	ϕ Argus	4	53 21	2'1	54 5'5	0'28	
187	η Antliæ	6-5	54 35	2'6	35 24'7	0'28	
188	Hydræ, 193 G.	6	59 44	2'8	23 48'0	0'29	
189	q Velorum	4	10 10 33	2'5	41 37'6	0'29	
190	ω Argus	4-3	11 22	1'4	69 32'5	0'30	
191	Velorum, 202 G.	6-7	16 12	2'4	47 11'8	0'30	
192	Antliæ, 64 G.	6-5	19 7	2'6	37 30'1	0'30	
193	I Carinæ	4-5	22 25	1'2	73 31'3	0'30	
194	α Antliæ	4-5	22 34	+2'7	30 33'5	-0'30	

No.	Name.	Mag.	R.A. 1900.			Ann. var.	Decl. 1900.		Ann. var.	Remarks.
			h	m	s	s	°	'	"	
195	<i>s</i> Carinæ	5-4	10	24	13	+2'2	58	13'7	-0'30	
196	<i>p</i> Carinæ	4-3		28	28	2'1	61	10'2	0'31	
197	44 Hydræ	6		29	15	2'8	23	13'8	0'31	
198	<i>p</i> Velorum	4		33	6	2'5	47	42'3	0'31	
199	γ Chamæleontis	4-5		34	17	0'7	78	5'4	0'31	
200	α Velorum	5		35	19	2'4	55	4'9	0'31	
201	θ Argus	3		39	23	2'1	63	52'2	0'31	
202	μ Argus	3		42	28	2'6	48	53'5	0'31	
203	δ^2 Chamæleontis	5		44	51	0'6	80	0'8	0'32	6 mag. pr. 32" b. 4'3
204	<i>u</i> Carinæ	4		49	25	2'4	58	19'3	0'32	
205	<i>i</i> Antliæ	5		52	3	2'8	36	35'9	0'32	
206	<i>i</i> Velorum	4-5		55	33	2'7	41	41'3	0'32	
207	χ Hydræ, 26 Her.	4-5	11	0	31	2'9	26	45'3	0'32	
208	Carinæ, 259 G.	6		3	14	2'1	70	20'2	0'32	
209	α Carinæ	5-4		4	19	2'5	58	26'0	0'32	
210	11 β Crateris	4		6	45	2'9	22	16'8	0'33	
211	Carinæ, 264 G.	6-5		8	37	2'5	63	37'5	0'32	
212	π Centauri	4-5		16	27	2'7	53	56'6	0'33	
213	Centauri, 29 G.	6-5		20	39	2'9	35	30'8	0'33	
214	ξ Hydræ	4		28	5	2'9	31	18'3	0'33	
215	ζ^2 Centauri	5-6		31	5	2'9	47	5'2	0'33	
216	λ Centauri	3-4		31	9	2'7	62	28'0	0'33	
217	π Chamæleontis	6		33	8	2'5	75	20'6	0'33	
218	σ Hydræ	5		35	14	3'0	34	11'4	0'33	
219	λ Muscæ	4		40	53	2'8	66	10'4	0'33	
220	Centauri, 65 G.	5-4		41	41	2'9	60	37'3	0'33	
221	Hydræ, 298 G.	6		43	42	3'0	26	11'6	0'33	
222	β Centauri	5		46	9	3'0	44	37'0	0'33	
223	Crucis, 2 G.	6		53	12	3'0	55	45'6	0'33	
224	ϵ Chamæleontis	5		54	39	2'9	77	39'8	0'33	
225	θ^1 Crucis	5-4		57	56	3'0	62	45'3	0'33	
226	Centauri, 88 G.	6-5		58	28	3'1	41	52'4	0'33	
227	δ Centauri	3	12	3	10	3'1	50	9'9	0'33	
228	2 ϵ Corvi	3		4	59	3'1	22	3'8	0'33	
229	δ Crucis	3-4		9	50	3'1	58	11'5	0'33	
230	ϵ Muscæ	5-4		12	11	3'2	67	24'2	0'33	
231	β Chamæleontis	5-4		12	27	3'4	78	45'4	0'33	
232	ϵ Crucis	4		15	58	+3'2	59	50'9	-0'33	

No.	Name.	Mag.	R.A. 1900.			Ann. var.	Decl. 1900.	Ann. var.	Remarks.
			h	m	s				
233	Centauri, 117 G.	7-6	12	19	51	+3°2	-41° 57'5	-0°33	
234	α^2 Centauri	6		20	6	3°1	34 37'9	0°33	
235	Hydrae, 323 G.	6-5		21	36	3°1	32 16'5	0°33	
236	σ Centauri	4-5		22	37	3°2	49 40'6	0°33	
237	γ Crucis	2		25	37	3°3	56 33'1	0°34	
238	γ Muscae	4		26	30	3°5	71 34'8	0°33	
239	9 β Corvi	2-3		29	7	3°1	22 50'5	0°33	
240	γ Centauri	2-3		36	0	3°3	48 24'6	0°33	
241	Hydrae, 330 G.	6		38	41	3°2	27 46'5	0°33	
242	β Muscae	3-4		40	8	3°6	67 33'6	0°33	
243	β Crucis	2-1		41	53	3°5	59 8'5	0°33	
244	p Centauri	5-6		45	16	3°2	33 27'2	0°33	
245	n Centauri	4-5		47	53	3°3	39 38'1	0°33	
246	δ Muscae	4-3		55	22	4°0	71 0'5	0°32	
247	ξ^2 Centauri	5	13	1	5	3°5	49 22'2	0°32	
248	Centauri, 177 G.	6		1	42	3°5	52 55'4	0°32	
249	Centauri, 183 G.	5-6		6	2	3°7	59 23'3	0°32	
250	η Muscae	5-6		8	28	4°0	67 21'8	0°32	
251	r Centauri	6-5		11	20	3°3	30 58'5	0°32	
252	Centauri, 196 G.	6		11	26	3°4	43 27'0	0°32	
253	46 γ Hydrae	3-4		13	29	3°2	22 38'5	0°32	
254	ι Centauri	3		14	59	3°4	36 11'0	0°32	
255	α Centauri	4-5		25	14	3°5	38 53'4	0°31	
256	Hydrae, 350 G.	6		27	2	3°3	28 10'7	0°31	
257	Chamaeleontis, 49 G.	6-7		30	38	5°0	75 10'4	0°31	
258	ϵ Centauri	3-2		33	33	3°8	52 57'5	0°31	
259	1 i Centauri	4-5		40	1	3°4	32 32'2	0°30	
260	M Centauri	5		40	19	3°8	50 55'8	0°30	
261	μ Centauri	3-4		43	36	3°6	41 58'5	0°30	
262	ζ Centauri	3-2		49	18	3°7	46 47'7	0°30	
263	Centauri, 294 G.	6-5		50	25	4°3	63 11'7	0°30	
264	ϕ Centauri	4		52	11	3°6	41 36'7	0°29	
265	47 Hydrae	6		52	55	3°4	24 29'1	0°29	
266	49 π Hydrae	4-3	14	0	40	3°4	26 11'9	0°29	
267	5 θ Centauri	3-2		0	48	3°5	35 52'6	0°30	11 mag. 3'
268	η Apodis	5-6		5	38	7°1	80 32'3	0°29	
269	ι Lupi	4		13	0	3°8	45 35'8	0°28	
270	v Centauri	5		13	20	+4°1	55 55'5	-0°28	

No.	Name.	Mag.	R.A. 1900.			Ann. var.	Decl. 1900.	Ann. var.	Remarks.
			h	m	s	s	°	'	"
271	Circini, 10 G.	6	14	16	48	+4.9	67	44.4	-0.28
272	α Centauri	5		16	53	3.7	39	3.2	0.28
273	Libræ, 3 G.	6-5		19	6	3.4	24	21.1	0.27
274	52 Hydræ	5-6		22	18	3.5	29	2.5	0.27
275	η Centauri	2-3		29	10	3.8	41	43.1	0.27
276	α Lupi	3.2		35	17	4.0	46	57.5	0.26
277	α Apodis	4		35	25	7.1	78	37.1	0.26
278	Circini, 19 G.	6		37	21	4.7	62	26.9	0.26 7 mag. pr. 1 ^m 46' a.5.4
279	ϵ^1 Centauri	4-5		37	32	3.6	34	44.5	0.26
280	δ Lupi	6		40	2	4.2	51	57.6	0.26 6 mag. seq. 11 ^s b.10.6
281	Apodis 18 G.	6		46	28	6.6	76	15.3	0.25
282	Circini, 29 G.	6		47	53	4.6	59	42.1	0.25
283	Centauri, 381 G.	6		49	36	3.7	33	27.0	0.25
284	β Lupi	3		51	58	3.9	42	43.9	0.25
285	γ Scorpii 1 Hev.	3-4		58	12	3.5	24	53.3	0.24
286	π Lupi	4-5		58	18	4.1	46	39.6	0.24
287	ζ Lupi	4-3	15	5	7	4.3	51	43.1	0.23
288	γ Trianguli austr.	3		9	33	5.5	68	18.6	0.23
289	β Circini	5-4		9	41	4.7	58	25.6	0.23
290	δ Lupi	4-3		14	48	3.9	40	17.1	0.22
291	ϕ^1 Lupi	4-3		15	28	3.8	35	53.9	0.22
292	κ^1 Apodis	6		20	36	6.4	73	2.5	0.22
293	ϵ Trianguli austr.	5-4		27	33	5.4	65	58.8	0.21
294	γ Lupi	3		28	8	4.0	40	49.9	0.21
295	Scorpii 3 Hev.	4-5		30	57	3.6	27	48.3	0.20
296	Normæ, 2 G.	6		31	24	4.4	52	2.6	0.20
297	5 χ Lupi	5-4		44	36	3.8	33	19.3	0.19
298	β Trianguli austr.	3		46	20	5.2	63	7.3	0.19
299	5 ρ Scorpii	5-4		50	42	3.7	28	55.3	0.18
300	7 δ Scorpii	2-3		54	25	3.5	22	20.2	0.17
301	δ Normæ	5		59	25	4.2	44	54.1	0.17
302	θ Lupi	5	16	0	1	3.9	36	31.8	0.17
303	10 ω^2 Scorpii	5		1	33	3.5	20	36.0	0.17 { 9 ω^1 4-5 mag. pr. 34 b. 12.0
304	κ Normæ	5-6		5	35	4.7	54	22.2	0.16
305	δ Trianguli austr.	4-5		6	20	5.4	63	25.8	0.16
306	γ^2 Normæ	5-4		12	21	4.5	49	54.6	0.15
307	20 σ Scorpii	3-4		15	7	3.6	25	21.1	0.15 9 mag. 21"
308	Scorpii, 62 G.	6		17	15	+4.0	38	57.6	-0.15

No.	Name.	Mag.	R.A. 1900.			Ann. var.	Decl. 1900.	Ann. var.	Remarks.
			h	m	s				
309	ζ Trianguli austr.	6-5	16	17	41	+6'3	-69° 51'6	-0'15	
310	γ Apodis	4		18	6	9'0	78 40'3	0'15	
311	Trianguli austr., 33 G.	6		21	56	5'3	61 24'7	0'14	
312	Normæ, 59 G.	6		22	27	4'3	46 1'3	0'14	
313	ν Scorp̄ii	5-4		24	51	3'9	34 29'2	0'14	
314	μ Normæ	5-6		26	58	4'2	43 50'0	0'13	
315	β Apodis	4-5		28	47	8'4	77 18'4	0'14	
316	23 τ Scorp̄ii	3-4		29	39	3'7	28 0'3	0'12	
317	α Trianguli austr.	2		38	4	6'3	68 50'6	0'12	
318	η Aræ	4		41	9	5'1	58 51'8	0'11	
319	26 ε Scorp̄ii	3		43	42	3'9	34 6'7	0'11	
320	μ ¹ Scorp̄ii	4-3		45	5	4'0	37 52'5	0'11	
321	ζ ² Scorp̄ii	4-3		47	33	4'2	42 11'4	0'11	
322	ζ Aræ	3		50	20	4'9	55 50'0	0'10	
323	24 Ophiuchi	6		50	46	3'6	22 59'5	0'10	
324	ε ¹ Aræ	4		51	37	4'8	53 0'4	0'10	
325	Scorp̄ii, 117 G.	6-5		55	25	3'9	31 59'7	0'09	
326	η Scorp̄ii	4-3	17	4	59	4'3	43 6'5	0'09	
327	Scorp̄ii, 139 G.	6		10	33	3'9	32 32'9	0'07	
328	ι Apodis	6		10	56	6'6	70 1'0	0'07	7 mag. pr. 1 ^m 49 ^s b. 5'4
329	40 ξ Ophiuchi	5		14	59	3'6	21 0'3	0'07	
330	42 θ Ophiuchi	3-4		15	52	3'7	24 53'9	0'06	
331	β Aræ	3		16	59	5'0	55 26'1	0'06	
332	44 Ophiuchi	4-5		20	15	3'7	24 5'0	0'06	
333	45 α Ophiuchi	5		20	57	3'8	29 46'5	0'06	
334	δ Aræ	4-3		22	4	5'4	60 36'0	0'06	
335	α Aræ	3		24	7	4'6	49 47'8	0'05	
336	51 Ophiuchi	5		25	18	3'7	23 53'1	0'05	
337	35 λ Scorp̄ii	2-3		26	49	4'1	37 1'8	0'05	
338	π Aræ	6		29	53	4'9	54 26'0	0'05	
339	θ Scorp̄ii	2		30	7	4'3	42 56'0	0'04	
340	κ Scorp̄ii	3-2		35	34	4'1	38 58'7	0'04	
341	η Pavonis	4-3		35	55	5'9	64 40'5	0'04	
342	μ Aræ	6-5		36	12	4'8	51 46'7	0'04	
343	ι ¹ Scorp̄ii	3-4		40	36	4'2	40 5'2	0'03	
344	3 X Sagittarii	4-6		41	15	3'8	27 47'5	0'03	
345	G Scorp̄ii	3-4		43	3	4'1	37 0'7	0'03	
346	Apodis, 66 G.	6		57	17	+8'4	75 53'5	-0'01	

No.	Name.	Mag.	R.A. 1900.	Ann. var.	Decl. 1900.	Ann. var.	Remarks.
			^h ^m ^s	^s	[°]		
347	π Pavonis	5-4	17 58 57	+ 5.8	-63 40.3	-0.01	
348	10 γ Sagittarii	3	59 23	3.8	30 25.6	0.00	
349	ϵ Telescopii	5	18 3 48	4.4	45 58.3	0.00	
350	13 μ Sagittarii	4	7 46	3.6	21 5.1	+0.01	
351	Telescopii, 6 G.	6-5	8 42	5.1	56 3.3	0.01	
352	η Sagittarii	3-4	10 51	4.1	36 47.5	0.01	
353	ξ Pavonis	4-5	14 0	5.5	61 32.4	0.02	
354	19 δ Sagittarii	3	14 35	3.8	29 52.3	0.02	
355	20 ϵ Sagittarii	2-3	17 32	4.0	34 25.9	0.02	
356	α Telescopii	3-4	19 33	4.4	46 1.5	0.02	
357	Pavonis, 30 G.	6-7	20 5	7.7	74 1.7	0.02	
358	22 λ Sagittarii	3	21 47	3.7	25 28.7	0.02	
359	θ Coronæ austr.	5	26 22	4.3	42 23.1	0.04	
360	ζ Pavonis	4	31 21	7.0	71 30.8	0.04	
361	Br. 2333	6	32 25	3.6	23 35.4	0.04	
362	λ Coronæ austr.	5-6	36 55	4.1	38 25.1	0.05	
363	Pavonis, 41 G.	6	37 25	7.4	73 6.2	0.05	
364	η^1 Coronæ austr.	6-5	41 37	4.3	43 47.4	0.06	
365	λ Pavonis	4-5	42 57	5.6	62 18.1	0.06	
366	30 Sagittarii	6-7	44 50	3.6	22 16.6	0.06	
367	κ Pavonis	5	46 38	6.2	67 21.6	0.06	
368	34 σ Sagittarii	2-3	49 4	3.7	26 25.2	0.07	
369	λ Telescopii	5	50 27	4.8	53 4.2	0.07	
370	ϵ Coronæ austr.	5-6	51 58	4.1	37 14.3	0.07	
371	38 ζ Sagittarii	3	56 14	3.8	30 1.4	0.08	{ dpl. 4 mag. & 4 mag. 0".4
372	ρ Telescopii	6-5	58 25	4.8	52 29.3	0.08	
373	40 τ Sagittarii	4-3	19 0 42	3.7	27 49.0	0.08	
374	α Coronæ austr.	4	2 40	4.1	38 3.7	0.08	
375	41 π Sagittarii	3	3 49	3.6	21 11.0	0.09	
376	Pavonis, 60 G.	6-5	7 9	6.1	66 50.0	0.09	
377	Coronæ austr., 49 G.	6-7	7 23	4.4	45 21.7	0.09	
378	α Sagittarii	4	16 57	4.2	40 48.2	0.11	
379	Telescopii, 59 G.	6	19 46	4.8	54 31.5	0.11	
380	Sagittarii, 186 G.	6	20 37	3.8	29 56.5	0.11	
381	ι Telescopii	5-6	27 48	4.5	48 18.8	0.12	
382	52 h Sagittarii	5-4	31 13	5.1	25 6.2	0.13	11 mag. 3"
383	Pavonis, 70 G.	6-5	37 53	7.0	72 44.8	0.13	
384	Sagittarii, 228 G.	6-5	39 39	+ 3.8	32 9.1	+0.14	

No.	Name.	Mag.	R.A. 1900.			Ann. var.	Decl. 1900.	Ann. var.	Remarks.
			^h	^m	^s				
385	ν Telescopii	5-6	19	39	51	+4.9	-56° 36'2"	+0.14	
386	56 <i>f</i> Sagittarii	5		40	32	3.5	20 0.0	0.14	
387	Pavonis, 75 G.	6		45	57	5.3	61 25.7	0.15	
388	ι Sagittarii	4-5		48	22	4.1	42 7.8	0.15	
389	ϵ Pavonis	4		49	2	7.0	73 10.5	0.15	
390	θ^1 Sagittarii	4-5		53	14	3.9	35 32.8	0.16	
391	62 <i>c</i> Sagittarii	5		56	30	3.7	27 59.3	0.16	
392	Sagittarii, 269 G.	6-7		57	49	3.6	22 52.0	0.16	
393	δ Pavonis	3-4		58	56	5.9	66 26.2	0.15	
394	ξ Telescopii	5-6		59	44	4.6	53 10.0	0.16	
395	4 Capricorni	6	20	12	9	3.5	22 7.1	0.18	
396	κ^1 Sagittarii	5-6		15	40	4.1	42 21.8	0.18	
397	α Pavonis	2		17	45	4.8	57 3.4	0.18	
398	Sagittarii, 296 G.	6		19	19	3.7	28 59.3	0.19	
399	ρ Pavonis	5		29	12	5.1	61 52.4	0.20	
400	μ^1 Octantis	6-7		29	41	7.6	76 31.8	0.20	
401	α Indi	3		30	32	4.2	47 38.4	0.20	
402	Microscopii, 13 G.	6		34	3	3.8	33 47.1	0.21	
403	β Pavonis	3-4		35	57	5.5	66 33.8	0.21	
404	η Indi	5-4		36	41	4.4	52 16.7	0.21	
405	16 ψ Capricorni	4-5		40	10	3.6	25 37.8	0.21	
406	ι Microscopii	5-6		41	42	4.1	44 21.1	0.21	
407	18 ω Capricorni	4-5		45	52	3.6	27 17.6	0.22	
408	β Indi	4-3		46	59	4.7	58 49.9	0.22	
409	Microscopii, 33 G.	6-5		47	10	3.9	40 11.0	0.22	
410	α Octantis	6-5		52	38	7.5	77 24.3	0.22	
411	γ Microscopii	5		55	9	3.7	32 39.0	0.23	
412	ζ Microscopii	5-6		56	34	3.9	39 1.2	0.23	
413	24 <i>A</i> Capricorni	5	21	1	17	3.5	25 24.3	0.24	
414	σ Pavonis	5-6		3	58	5.7	70 32.1	0.24	
415	Indi, 23 G.	6		8	38	4.3	53 40.1	0.24	
416	4 Piscis austr.	5		11	52	3.6	32 35.4	0.25	
417	θ^1 Microscopii	5		14	22	3.8	41 14.0	0.25	
418	γ Pavonis	4-5		18	11	5.0	65 49.1	0.27	
419	γ Indi	6-7		19	8	4.3	55 5.6	0.25	
420	34 ζ Capricorni	4		20	58	3.4	22 50.7	0.26	
421	Gruis, 3 G.	6		26	55	3.9	45 17.5	0.26	
422	Indi, 40 G.	6-7		30	4	+4.9	65 16.3	+0.26	

No.	Name.	Mag.	R.A. 1900.			Ann. var.	Decl. 1900.	Ann. var.	Remarks.
			^h	^m	^s				
423	ν Octantis	4	21	30	22	+6 ⁸ 9	-77 48 ⁶ 9	+0 ¹ 26	
424	41 Capricorni	6-5		36	18	3 ⁴	23 42 ⁹	0 ² 7	
425	9 ι Piscis austr.	5		39	0	3 ⁶	33 29 ⁰	0 ² 7	
426	o Indi	6-5		42	21	5 ²	70 5 ⁶	0 ² 7	
427	γ Gruis	3		47	52	3 ⁶	37 50 ²	0 ² 8	
428	δ Indi	5		51	7	4 ¹	55 28 ¹	0 ² 8	
429	Capricorni, 134 G.	7-6		53	9	3 ³	21 39 ⁶	0 ² 8	
430	ϵ Indi	5		55	43	4 ⁶	57 11 ⁸	0 ² 5	
431	λ Gruis	5-4	22	0	6	3 ⁶	40 1 ⁵	0 ² 9	
432	α Gruis	2		1	56	3 ⁸	47 26 ⁷	0 ² 9	
433	14 μ Piscis austr.	5-4		2	33	3 ⁵	33 28 ⁶	0 ² 9	
434	16 λ Piscis austr.	5		8	38	3 ⁴	28 15 ⁷	0 ² 9	
435	ϵ Octantis	6-5		8	50	7 ¹	80 56 ³	0 ² 9	
436	μ^1 Gruis	5		9	36	3 ⁶	41 50 ⁷	0 ² 9	
437	α Tucanæ	3		11	38	4 ²	60 45 ⁵	0 ² 9	
438	Gruis, 37 G.	6-5		11	41	3 ⁹	54 6 ³	0 ³ 0	
439	ν Indi	6-5		15	55	5 ⁰	72 44 ²	0 ³ 0	
440	47 Aquarii	6-5		16	6	3 ³	22 5 ⁸	0 ³ 0	
441	ν Gruis	6 5		22	47	3 ⁵	39 38 ²	0 ³ 0	7 mag. pr. 25 ^a b. 2 ^a
442	δ^1 Gruis	4		23	18	3 ⁶	44 0 ⁴	0 ³ 0	{ δ^2 4-5 mag. seq. 30 a. 15 ¹ 3
443	ν Tucanæ	5-6		26	15	4 ¹	62 29 ⁸	0 ³ 0	
444	59 ν Aquarii	5-6		29	13	3 ³	21 13 ¹	0 ³ 1	
445	Piscis austr., 49 G.	6		33	13	3 ⁴	33 36 ²	0 ³ 1	
446	18 ϵ Piscis austr.	4		35	7	3 ³	27 34 ⁰	0 ³ 1	
447	β Octantis	4-5		35	53	6 ⁶	81 54 ⁴	0 ³ 1	
448	β Gruis	2		36	42	3 ⁶	47 24 ⁵	0 ³ 1	
449	ϵ Gruis	3-4		42	31	3 ⁶	51 50 ⁶	0 ³ 1	
450	Gruis, 69 G.	6		45	21	3 ⁴	39 41 ²	0 ³ 2	
451	Tucanæ, 18 G.	6		45	41	3 ⁹	63 43 ¹	0 ³ 2	
452	22 γ Piscis austr.	5-4		46	58	3 ³	33 24 ⁴	0 ³ 2	9 mag. 4"
453	ρ Indi	6		47	43	4 ³	70 36 ⁵	0 ³ 2	
454	ζ Gruis	4		54	58	3 ⁶	53 17 ⁴	0 ³ 2	
455	Indi, 80 G.	6		58	16	4 ⁰	69 21 ⁷	0 ³ 2	
456	θ Gruis	4	23	1	15	3 ⁴	44 3 ⁷	0 ³ 2	
457	86 c^1 Aquarii	4-5		1	19	3 ²	24 17 ⁰	0 ³ 2	
458	88 c^2 Aquarii	4		4	7	3 ²	21 42 ⁹	0 ³ 2	
459	ι Gruis	4		4	42	3 ⁴	45 47 ³	0 ³ 2	Com. 10 mag.
460	Tucanæ, 25 G.	6-5		10	57	+3 ⁶	62 32 ⁷	+0 ³ 3	

No.	Name.	Mag.	R.A. 1900.				Ann. var.	Decl. 1900.		Ann. var.	Remarks.
			h	m	s	s		°	'	"	
461	γ Tucanæ	4	23	11	36	+3'5	-58	47'0	+0'33		
462	γ Sculptoris	4-5		13	25	3'2		33	4'7	0'32	
463	Sculptoris, 11 G.	6		15	56	3'2		27	32'0	0'33	
464	98 δ^1 Aquarii	4-5		17	44	3'1		20	38'7	0'33	
465	α Gruis	6-5		21	1	3'4		53	16'6	0'33	
466	Tucanæ, 33 G.	6		23	14	3'5		63	39'7	0'33	
467	Octantis, 83 G.	6		26	52	4'0		77	56'3	0'33	
468	β Sculptoris	5		27	37	3'2		38	22'2	0'33	
469	101 δ^3 Aquarii	5-4		28	3	3'1		21	28'0	0'33	
470	ι Phœnicis	4-5		29	42	3'2		43	10'0	0'33	
471	Phœnicis, 11 G.	4-5		32	28	3'2		46	2'7	0'33	
472	μ Sculptoris	5-6		35	23	3'2		32	37'6	0'33	
473	Tucanæ, 35 G.	6-7		38	41	3'5		71	2'9	0'33	
474	σ Phœnicis	5		41	57	3'2		50	46'9	0'33	
475	δ Sculptoris	5-4		43	43	3'1		28	41'0	0'33	
476	Aquarii, 274 G.	6-7		48	11	3'1		24	47'1	0'33	
477	π Phœnicis	5		53	44	3'1		53	18'3	0'33	
478	ϵ Tucanæ	4-5		54	43	3'2		66	8'0	0'33	
479	θ Octantis	5-6		56	29	3'2		77	37'0	0'33	
480	Tucanæ, 45 G.	6		59	37	+3'1	-71	59'6	+0'33		

*Measures of Southern Double Stars, made at the Observatory,
Sydney, New South Wales.*

(Communicated by H. C. Russell, B.A., F.R.S.)

The following are measures of interesting southern double stars made at Sydney Observatory during 1886 with two measures of α Centauri in 1884. With a view of testing the measures of position-angles several measures of α Centauri have been made. Taking $\Delta\alpha$ and $\Delta\delta$, it will be seen that the results obtained in this way by Mr. Pollock are rather less than his direct measures, but he thinks his direct measures are more reliable. There is some discrepancy in the measures of h 5028, the large star of which Burnham discovered to be double (B 759), and β makes the distance of the wide pair $34''\cdot81$. Herschel gives two measures with his reflector distances, $20''$ and $15''$, and the Sydney measure in 1886 is $15''\cdot27$.

Results of Measures of α Centauri, Sydney Observatory, 1884 and 1886.

Star.	R.A. 1886. h m s	Decl. 1886. ° ' "	Pos. Angle.	Dist. "	Mags.	Date.	Observer.	Instrument.
α Centauri	14 31 52	- 60 21 46	199° 0'	11° 96'	1-1½	1884.194	R.	11½
			202° 7'	14° 78'		86.296	P.	7¼
			202° 9'	15° 02'		86.301	P.	7¼
			202° 7'	15° 09'		86.320	P.	7¼
			202° 3'	14° 73'		86.326	P.	7¼
			200° 4'	14° 74'		86.378	R.	11½
			201° 9'	14° 84'		86.378	P.	11½
			201° 2'	15° 19'		86.520	R.	11½
			201° 9'	15° 37'		86.526	P.	7¼
			202° 3'	14° 70'		86.534	P.	7¼
			202° 6'	15° 06'		86.548	P.	7¼
			202° 2'	15° 15'		86.550	P.	7¼
			202° 7'	--		86.550	P.	7¼
			202° 7'	14° 96'		86.553	P.	7¼
			203° 1'	15° 25'		86.567	P.	7¼
			202° 2'	15° 21'		86.570	P.	7¼
			202° 6'	15° 00'		86.583	P.	7¼
			202° 5'	14° 96'		86.594	P.	7¼
			202° 1'	15° 63'		86.602	P.	7¼
Mean ...	...	...	Epoch.	Pos. Angle.	No. of Meas.			
			1886.449	200° 80'	2			
			1886.487	202° 46'	16			

Definition bad.

Stars very blazy.

Stars very blazy.

Definition very unsteady.

Definition awful.

4 o'clock P.M.

2.30 P.M., stars dancing.

4.30 P.M., stars very steady.

Pos. angle satisfactory.

Definition very steady.

Definition good.

Resulting Position-angles and Distances of α Centauri obtained from Measures $\Delta\alpha$ and $\Delta\delta$, Sydney Observatory, 1884 and 1886.

Pos. Angle.	Distance.	Date.	Observer.	Instrument.
199° 5'	12' 32"	1884.433	R.	11 $\frac{1}{2}$
200° 7'	14' 68"	86.526	P.	7 $\frac{1}{4}$
200° 9'	14' 82"	86.548	P.	7 $\frac{1}{4}$
201° 8'	14' 78"	86.550	P.	7 $\frac{1}{4}$
200° 7'	15' 19"	86.567	P.	7 $\frac{1}{4}$
Observer.	Epoch.	Pos. Angle.	Dist.	No. of Meas.
... P.	1886.548	201° 02'	14' 87"	4
Mean...				

Measures of some Southern Binaries and Double Stars showing signs of Motion, made at Sydney Observatory during the year 1886.

Star.	R.A. 1886°.	Dec. 1886°.	Pos. Angle.	Dist.	Mags.	Date.	Obs.	Instr.
γ Eridani	1 35 28	-56 46 27	{ 229° 0' "	6' 63"	6-6	1886.901	P.	11 $\frac{1}{2}$ Definition very bad.
			{ 230° 8'	6' 85"	"	86.909	P.	11 $\frac{1}{2}$ Definition good.
β Muscæ	12 39 18	-67 29 2	{ 322° 0'	0' 79"	3.5-4	86.501	R.	11 $\frac{1}{2}$ }
			{ 325° 8'	0' 5 est.	"	86.594	P.	7 $\frac{1}{4}$ }
			{ 323° 7'	—	"	86.597	P.	7 $\frac{1}{4}$ }
							Discovered double by Russell 78.284.	
							Previous measure— R 80.344 Pos. 317° 0.3 Dist. 0".54	
π Lupi	14 57 22	-46 36 15	91° 1'	0' 87"	5-5	86.550	P.	7 $\frac{1}{4}$ Previous measures—
			89° 8'	0' 8 est.	—	86.597	P.	7 $\frac{1}{4}$ Pos. 111° 0.1 Dist. 0".75
								R 1872.422 " 100° 0.1 " 0".57
								R 1880.444 " 99° 3 " 0".90

β 755	6 31 26	-36 41	$\left\{ \begin{array}{l} 252.3 \\ 253.0 \\ 302.0 \end{array} \right.$	$\left\{ \begin{array}{l} 0.88 \\ 0.67 \\ 21.22 \end{array} \right.$	$\left\{ \begin{array}{l} 6-7 \\ \\ 6-12 \end{array} \right.$	$\left\{ \begin{array}{l} 1887.227 \\ 87.246 \\ 87.246 \end{array} \right.$	$\left\{ \begin{array}{l} P. \\ P. \\ P. \end{array} \right.$	$\left\{ \begin{array}{l} 11\frac{1}{2} \\ 11\frac{1}{2} \\ 11\frac{1}{2} \end{array} \right.$ A and B. A and B dist. much too small; estimated 1".0. A and C. β at Mount Hamilton 1879: A and B $250^{\circ} \pm 1''0 \pm$. A and C $300^{\circ} \pm 12''0 \pm$			
β 757	7 8 23	-36 21	67.7	2.57	6-9	87.227	P.	11 $\frac{1}{2}$ A pretty double, but much wider than B makes it; est. dist. = $3''0 \pm$. β at Mount Hamilton, 1879: $60^{\circ} \pm 1''.5 \pm$.			
β 759	18 4 19	-36 48	$\left\{ \begin{array}{l} 121.7 \\ 148.7 \end{array} \right.$	$\left\{ \begin{array}{l} 2.17 \\ 15.27 \end{array} \right.$	9-9.5	86.605	P.	7 $\frac{1}{2}$ A and B β at Mount Hamilton: A and B $118^{\circ}.1'1''.20$			
9-9					86.605	P.	A and C β 179.681. A and C $149^{\circ}.2'34''.81$ 179.681. Dist. of A and C Sydney readings of micro. screw 186.605 are Revs. 24.713 26.123 24.726 26.113 26.1180 24.7195				
Coincidence found by direct measures 25.422.											
Value of screw = $21''.835$ $\therefore$ dist. = $15''.27$.											
β 760	18 9 55	-36 48	99.5	4.36	3-11	86.712	P.	11 $\frac{1}{2}$ A fine double with a distant companion, 10 mag. about $300^{\circ} \pm$. Mean of β 's measures is: Pos. $99^{\circ}.9$ Dist. $2''.85$ 1879.676.			
β 761	19 31 49	-40 0	198.7	2.55	7-11	86.712	P.	11 $\frac{1}{2}$ Mean of β 's measures is: Pos. $197^{\circ}.4$, Dist. $1''.92$ 1879.684.			
β 763	20 16 8	-42 50	310 est. 0.7	7-8	7-8	86.605	P.	7 $\frac{1}{2}$ β 's measures are: Pos. $28^{\circ}.6$ Dist. $1''.23$ 1879.687. $19^{\circ}.9$ $1''.25$ 79.753.			
β 766	21 17 9	-41 30	302.0 est. 0.5	6-7	6-7	86.706	P.	11 $\frac{1}{2}$ Definition very bad. Mean of β 's measures is: Pos. $314^{\circ}.2$ Dist. $0''.84$ 179.727.			
β 768	21 48 55	-37 51				86.605	R.	11 $\frac{1}{2}$ A large star following γ Gruis examined with 800 and 1200, not divided, though it seems elongated in direction of motion; angle $90^{\circ} \pm$. Only thought double by β .			
β 767	21 19 48	-43 3	146.3	3.47	6-9	86.602	P.	7 $\frac{1}{2}$ Mean of β 's measures are: Pos. $146^{\circ}.1$ Dist. $4''.05$ 179.709.			

Observations of the Companion of Sirius made at the Dearborn Observatory, Chicago, U.S.A. By Prof. G. W. Hough, Director.

(Communicated by the Secretaries.)

Date.	Sid. Time.	<i>p.</i>	<i>s.</i>	Remarks.
	^h	[°]	["]	
1887-118	5.9	24.7	—	High winds. Unsteady.
148	6.6	24.4	6.90	Difficult.
186	7.5	23.7	clouded	Comp. plain.
211	7.2	23.7	6.80	Difficult.
217	7.5	23.2	6.77	Comp. plain. Vis. with 925 power.
236	8.0	23.1	6.65	Difficult. Clouds passing.
249	7.8	23.3	6.77	Difficult. Hazy.

Mean Results.

1887-195	23.7	6.78
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During the past spring the weather here has been very unfavourable. It is the first year that I have found any difficulty in securing observations of *Sirius* on as many nights as was desirable. The decrease in the distance, however, makes the observation of this pair more difficult every year, and hence requires better atmospheric conditions than formerly.

On the Orbit of Σ 1757. By J. E. Gore.

A reference to my paper on the orbit of this binary star in the *Monthly Notices* for November 1886 will show that the comparison between the measures of position angles in recent years and the angles computed from the elements there given is not satisfactory. I have re-computed the orbit, using recent measures kindly made for me by Mr. Tarrant and Prof. Young (U.S.A.), and now find the following elements:—

Second Elements of Σ 1757.

$P = 276.92$ years	$\Omega = 87^\circ 36'$
$T = 1791.98$ A.D.	$\lambda = 185^\circ 23'$
$e = 0.4498$	$a = 2.05''$
$\gamma = 40^\circ 56'$	$\mu = +1.30^\circ$

The following is a comparison between the observations and the positions computed from the above elements:—

Epoch.	Observer.	θ_o	θ_c	$\theta_o - \theta_c$	ρ_o	ρ_c	$\rho_o - \rho_c$
1825.37	Struve	10.0	10.47	-0.47	1.60	1.26	+0.34
1829.82	"	19.5	19.57	-0.03	1.44	1.37	+0.07
1832.39	Smyth	24.1	24.19	-0.09	1.5	1.44	+0.06
1833.38	Struve	23.9	25.83	-1.93	1.54	1.46	+0.08
1835.37	"	25.5	29.03	-3.53	1.66	1.51	+0.15
1836.42	"	29.4	30.67	-1.27	1.64	1.53	+0.11
1838.48	Smyth	31.0	33.62	-2.62	1.7	1.58	+0.12
1841.38	Mädler	36.0	37.48	-1.48	1.74	1.66	+0.08
1842.39	Dawes	37.4	38.72	-1.32	1.67	1.69	-0.02
1842.52	Smyth	37.9	38.89	-0.99	1.7	1.69	+0.01
1843.45	Dawes	38.8	40.00	-1.2	—	1.70	—
1843.51	Kaiser	40.9	40.07	+0.83	—	1.71	—
1844.72	O. Struve	43.7	41.50	+2.20	1.89	1.74	+0.15
1845.88	Mädler	40.8	42.77	-1.97	2.02	1.77	+0.25
1850.38	O. Struve	48.8	47.43	+1.37	1.85	1.89	-0.04
1852.38	Smyth	51.7	49.25	+1.45	2.0	1.94	+0.06
1853.09	Mädler	52.2	49.98	+2.22	2.05	1.96	+0.09
1853.73	Jacob	48.0	50.54	-2.54	2.14	1.98	+0.16
1854.37	Mädler	50.1	51.10	-1.00	2.16	1.99	+0.17
1855.31	"	51.3	51.96	-0.66	1.7	2.01	-0.31
1856.32	"	51.8	52.80	-1.00	1.5	2.04	-0.54
1856.42	Morton	51.9	52.89	-1.01	2.01	2.04	-0.03
1856.88	Secchi	52.9	53.27	-0.37	1.84	2.05	-0.21
1857.29	Morton	54.2	53.61	+0.59	2.00	2.06	-0.06
1858.08	Jacob	52.8	54.24	-1.44	1.76	2.07	-0.31
1858.37	Mädler	54.7	54.47	+0.23	1.91	2.08	-0.17
1859.36	"	53.7	55.24	-1.54	1.82	2.11	-0.29
1860.34	Dawes	54.3	56.03	-1.73	2.31	2.13	+0.18
1860.35	"	53.4	56.03	-2.63	2.08	2.13	+0.05
1863.32	Dembowski	59.0	58.23	+0.77	2.01	2.20	-0.19
1865.97	"	60.4	60.06	+0.34	2.09	2.25	-0.16
1866.01	O. Struve	60.8	60.09	+0.71	2.34	2.25	+0.09
1867.27	Talmage	63.7	61.00	+2.70	2.60	2.28	+0.32
1868.30	Dembowski	62.7	61.65	+1.05	2.04	2.30	-0.26
1869.22	Brünnow	63.4	62.25	+1.15	2.59	2.32	+0.27
1869.24	Talmage	64.3	62.25	+2.05	—	2.32	—
1870.15	Dembowski	63.5	62.87	+0.63	2.03	2.34	-0.31
1870.37	Talmage	64.1	63.00	+1.10	2.00	2.34	-0.34
1871.19	Dembowski	63.4	63.52	-0.12	2.13	2.35	-0.22

Epoch.	Observer.	θ_0	θ_c	$\theta_0 - \theta_c$	p_0	p_c	$p_0 - p_c$
1872.33	Wilson & Seabroke	64.8	64.25	+0.55	2.30	2.37	-0.07
1872.37	Talmage	67.3	64.27	+3.03	—	2.37	—
1873.23	Wilson & Seabroke	64.0	64.80	-0.80	2.05	2.38	-0.33
1873.35	„	65.0	64.87	+0.13	2.00	2.38	-0.38
1874.32	„	65.5	65.45	+0.05	2.15	2.40	+0.25
1874.32	Talmage	69.8	65.45	+4.35	1.08?	2.40	-1.32?
1874.41	Wilson & Seabroke	64.2	65.50	-1.30	2.16	2.40	-0.24
1875.31	Schiaparelli	66.6	66.03	+0.57	2.00	2.42	-0.42
1876.36	Wilson & Seabroke	67.2	66.64	+0.56	2.15	2.44	-0.29
1876.41	„	66.5	66.67	-0.17	2.21	2.45	-0.24
1879.40	Hall	68.9	68.40	+0.50	2.33	2.50	-0.17
1879.470	Schiaparelli	67.98	68.40	-0.42	2.462	2.50	-0.038
1882.467	„	69.38	70.00	-0.62	2.314	2.55	-0.236
1883.21	Engelmann	70.44	70.43	+0.01	2.623	2.56	+0.063
1887.213	Tarrant	72.44	72.52	-0.08	2.62	2.62	0.00
1887.356	Young	72.75	72.59	+0.16	2.79	2.62	+0.17

I have computed the following short ephemeris:—

Date.	Position Angle.	Distance.
1890.0	73.91°	2.73"
1895.0	76.32	2.78
1900.0	78.64	2.83

On the Formulae for Correcting Approximate Elements of the Orbits of Binary Stars. By A. Marth.

The present communication, a supplement of the paper in the April number of the *Monthly Notices*, pp. 333-46, is intended to point out the alterations and modifications of the formulæ there given, which render them applicable to the orbits of binary stars, and to offer some remarks connected therewith.

While in the case of the orbit of a satellite belonging to the solar system the apparent orbit, or the projection of the true orbit on a plane perpendicular to the line of vision, changes continually with the changing position of the Earth relative to the planet, in the case of a binary system the plane of projection remains unaltered, and may therefore properly be adopted as the plane to which the plane of the orbit is referred.

Let Ω_0 denote the position-angle of the line of nodes of the two planes, reckoned from the declination-circle passing through the star at the time t_0 , Ω the same angle reckoned from the declination-circle at the time t , so that

$$\Omega = \Omega_0 + 0^{\circ}.00557 \sin \alpha \cdot \sec \delta \cdot (t - t_0).$$

Let i be the inclination of the two planes, and let it be taken between 0° and 90° , if the apparent motion of the comes is in the direction of *increasing* position-angles, and between 90° and 180° , if the motion is in the direction of *decreasing* position-angles, so that there may be no need to make a distinction between direct and retrograde motion in the orbit.

Further, let ω denote the angle between the node and the lower apsis in the direction of the real motion in the orbit; $e = \sin \phi$ the eccentricity; a the major semi-axis of the orbit, expressed in seconds of arc; $a\rho$ the radius vector, μ, ϵ, v the mean, eccentric, and true anomaly of the comes at the time t ; μ_0 its mean anomaly at the time t_0 ; n its yearly mean orbital motion.

The true anomaly v of the comes and its radius vector ρ , expressed in parts of a , being found by the usual formulæ

$$\begin{aligned}\epsilon - e^\circ \cdot \sin \epsilon &= \mu = \mu_0 + n(t - t_0) & e^\circ &= 57^\circ \cdot 296 \cdot e, \\ \rho \sin v &= \sin \epsilon \cdot \cos \phi \\ \rho \cos v &= \cos \epsilon - e,\end{aligned}$$

the values of the position-angle p and of the distance s of the comes for the time t are found by

$$\begin{aligned}\sin \sigma \sin (p - \Omega) &= \sin (v + \omega) \cos i \\ \sin \sigma \cos (p - \Omega) &= \cos (v + \omega) \\ s &= a\rho \cdot \sin \sigma.\end{aligned}$$

Formulæ for correcting the assumed elements by means of equations of condition between observed and computed position-angles have been published by Mädler (*Astron. Nachr.*, vol. xvi. p. 36); also by Schur (*Astron. Nachr.*, vol. lxxi. p. 24), and perhaps in other papers, not at present within my reach. To be really efficient, such formulæ require that the assumed elements should be fairly approximate, but a rather wide field is left for their useful application. In the case of elements of questionable character, or even of first attempts, the formation of the equations of condition ought not to be neglected, for their mere aspect may prove to the computer the inadequacy of the observations at his disposal for a fair determination of the orbit; or if it does not prevent the publication of premature results of very doubtful value, it will at least prevent their undue acceptance by readers competent to form their own judgment.

Introducing for greater simplicity, as in the case of the orbit of a satellite belonging to the solar system—

$$\begin{aligned}\sin \sigma \sin \tau &= + \cos i \\ \sin \sigma \cos \tau &= - \sin i \cos (v + \omega) \\ \cos \sigma &= + \sin i \sin (v + \omega),\end{aligned}$$

the differentiation of the equations for p and s gives

$$\begin{aligned}\sin \sigma dp &= \sin \tau \cdot d(v + \omega) + \cos \tau \cdot \sin(v + \omega) \cdot di + \sin \sigma d\Omega \\ d\sigma &= \cos \tau \cdot d(v + \omega) - \sin \tau \cdot \sin(v + \omega) \cdot di.\end{aligned}$$

If e and i , eccentricity and inclination, are not of small amount, the equations of condition between the differences of the observed and computed position-angles and distances and the variations of the assumed elements will be

$$\begin{aligned}\rho \sin \sigma \cdot \delta p &= + \sin \tau \frac{\cos \phi}{\rho} \cdot [\delta \mu_0 + (t - t_0) \delta n] \\ &\quad + \rho \sin \tau \cdot \delta \omega \\ &\quad + \sin \tau (\sin v \cos \phi + \sin \epsilon) \cdot \delta \phi \\ &\quad + \rho \cos \tau \cdot \sin(v + \omega) \cdot \delta i \\ &\quad + \rho \sin \sigma \cdot \delta \Omega \\ \frac{57.3}{u} \cdot \delta s &= + (\cos \sigma \cos \tau \cdot \frac{\cos \phi}{\rho} + \tan \phi \sin \sigma \sin v) \cdot (\delta \mu_0 + (t - t_0) \delta n) \\ &\quad + \rho \cos \sigma \cos \tau \cdot \delta \omega \\ &\quad + [\cos \sigma \cos \tau (\sin v \cos \phi + \sin \epsilon) - \sin \sigma \cos v \cos \phi] \cdot \delta \phi \\ &\quad - \rho \cos \sigma \sin \tau \cdot \sin(v + \omega) \cdot \delta i \\ &\quad + \rho \sin \sigma \cdot \frac{57.3}{u} \delta \alpha.\end{aligned}$$

In cases of moderate or small eccentricity it will be safer to substitute

$$\begin{aligned}\rho \sin \sigma \cdot \delta p &= + \sin \tau \cdot (1 + e \cos v) \cdot [\sec \phi \delta(\mu_0 + \omega) + (t - t_0) \cdot \sec \phi \cdot \delta n] \\ &\quad - \sin \tau \cdot (\cos v + \cos \epsilon \cos \phi + \tan \frac{1}{2} \phi) \cdot 57.3 (\tan \phi + \delta e) \sin \delta \omega \\ &\quad + \sin \tau \cdot (\sin v + \sin \epsilon \sec \phi) \cdot 57.3 [(\tan \phi + \delta e) \cos \delta \omega - \tan \phi] \\ &\quad + \rho \cos \tau \cdot \sin(v + \omega) \cdot \delta i \\ &\quad + \rho \sin \sigma \cdot \delta \Omega \\ \frac{57.3}{u} \cdot \delta s &= + [\cos \sigma \cos \tau \cdot (1 + e \cos v) + e \sin \sigma \sin v] [\sec \phi \delta(\mu_0 + \omega) \\ &\quad + (t - t_0) \sec \phi \cdot \delta n] \\ &\quad - [\cos \sigma \cos \tau \cdot \cos v + \cos \epsilon \cos \phi + \tan \frac{1}{2} \phi] + \sin \sigma \sin v \\ &\quad \cdot 57.3 (\tan \phi + \delta e) \sin \delta \omega \\ &\quad + [\cos \sigma \cos \tau \cdot (\sin v + \sin \epsilon \sec \phi) - \sin \sigma \cos v] \\ &\quad \cdot 57.3 [(\tan \phi + \delta e) \cos \delta \omega - \tan \phi] \\ &\quad - \rho \cos \sigma \sin \tau \cdot \sin(v + \omega) \cdot \delta i \\ &\quad + \rho \sin \sigma \cdot \frac{57.3}{u} \delta \alpha.\end{aligned}$$

If the assumed orbit is circular and the orbital longitude of the comes from the node is $= u$, the equations become

$$\begin{aligned} \sin \sigma \delta p &= + \sin \tau \cdot [\delta u_0 + (t - t_0) \delta n] \\ &\quad - \sin \tau \cdot \cos u \cdot 2\phi \sin \omega \\ &\quad + \sin \tau \cdot \sin u \cdot 2\phi \cos \omega \\ &\quad + \cos \tau \cdot \sin u \cdot \delta i \\ &\quad + \sin \sigma \cdot \delta \Omega \\ \frac{57.3}{a} \delta s &= + \cos \sigma \cos \tau [\delta u_0 + (t - t_0) \delta n] \\ &\quad - (\cos \sigma \cos \tau \cdot \cos u + \frac{1}{2} \sin \sigma \cdot \sin u) \cdot 2\phi \sin \omega \\ &\quad + (\cos \sigma \cos \tau \cdot \sin u + \frac{1}{2} \sin \sigma \cdot \cos u) \cdot 2\phi \cos \omega \\ &\quad - \cos \sigma \cdot \sin \tau \cdot \sin u \cdot \delta i \\ &\quad + \sin \sigma \cdot \frac{57.3}{a} \delta a. \end{aligned}$$

In case the inclination of the orbit to the plane of projection is not considerable, the determination of the line of nodes becomes uncertain, and this uncertainty develops with the decrease of inclination rapidly into indeterminateness. The uncertainty of fixing the position of the plane of the orbit may be easily estimated by the reflection that in order that the maximum effect of the inclination upon the position-angles may reach the amount of

0°·5	1°·0	1°·5	2°·0
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the inclination must amount to

10°·7	15°·1	18°·4	21°·2
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the corresponding maximum of the foreshortening of the radius vector being

0·017	·034	·051	0·067
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or	1 : 58	29	20	15.
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A fair determination of Ω and i and consequently of ω being, under such circumstances, not practicable, they cannot serve directly as elements of the orbit, but ought to be supplanted by such functions or such other elements as will practically represent whatever can be fairly established concerning the position of the orbit, without erring either on the one side by a display of untrustworthy figures, or, on the other, by the assumption or suggestion of entire uncertainty.

The proper selection of the most suitable elements for the purpose does not appear to me doubtful. The choice will be different, according as the eccentricity of the orbit is considerable or not.

In case the orbit is so eccentric that the place of the chief star in the projected orbit is considerably distant from the centre,

the substitution of the position-angle P of the periastræ for that of the line of nodes as an element recommends itself at once, and the selection of

$$\tan \nu = \frac{\sin^2 i \sin \omega \cos \omega}{1 - \sin^2 i \sin^2 \omega} \text{ and of } k = \frac{\cos i}{1 - \sin^2 i \sin^2 \omega}$$

as the two other new elements will be found a suitable one in the course of some simple considerations.

If in the equations for finding p and $\sin \sigma$

$$\sin \sigma \sin (p - \Omega) = \sin (v + \omega) \cos i$$

$$\sin \sigma \cos (p - \Omega) = \cos (v + \omega)$$

the true anomaly v is put $= 0^\circ$, they supply the position-angle P of the periastræ and the corresponding value of $\sin \sigma$, say $\sin \sigma_0$:

$$\sin \sigma_0 \sin (P - \Omega) = \sin \omega \cos i$$

$$\sin \sigma_0 \cos (P - \Omega) = \cos \omega$$

and thereby

$$\sin^2 \sigma_0 = 1 - \sin^2 i \sin^2 \omega.$$

The substitution of these values in the preceding equations gives

$$\sin \sigma_0 \cdot \sin \sigma \sin (p - P) = \sin v \cdot \cos i$$

$$\sin \sigma_0 \cdot \sin \sigma \cos (p - P) = \cos v \cdot (1 - \sin^2 i \sin^2 \omega) - \sin v \cdot \sin^2 i \sin \omega \cos \omega$$

$$\text{or } \frac{\sin \sigma}{\sin \sigma_0} \cdot \sin (p - P) = \sin v \cdot \frac{\cos i}{1 - \sin^2 i \sin^2 \omega}$$

$$\frac{\sin \sigma}{\sin \sigma_0} \cdot \cos (p - P) = \cos v - \sin v \cdot \frac{\sin^2 i \sin \omega \cos \omega}{1 - \sin^2 i \sin^2 \omega}.$$

By the introduction of the position-angle

$$P = P_0 + 0^\circ.00557 \sin \alpha \cdot \sec \delta \cdot (t - t_0) \text{ of the periastræ,}$$

and of

$$\frac{\cos i}{1 - \sin^2 i \sin^2 \omega} = k \text{ and } \frac{\sin^2 i \cdot \sin \omega \cos \omega}{1 - \sin^2 i \sin^2 \omega} = \tan \nu$$

as the new elements, the equations for finding p and s become, if (s) is written instead of

$$\frac{\rho \sin \sigma}{\sin \sigma_0}$$

and (a) instead of $a \sin \sigma_0$ or $a \sqrt{1 - \sin^2 i \sin^2 \omega}$,

$$(s) \sin (p - P) = \rho \sin v \cdot k = \sin \epsilon \cdot k \cos \phi$$

$$(s) \cos (p - P) = \rho \cos v - \rho \sin v \cdot \tan \nu = \cos \epsilon - \sin \epsilon \cdot \tan \nu \cdot \cos \phi - e$$

$$s = (a) \cdot (s)$$

If the plane of the orbit coincides with the plane of projection, the value of $\tan \nu$ is $= 0$ and that of $k = +1$ or -1 according as the apparent motion of the comet is in the direction of in-

creasing or decreasing position-angles. The values of $\tan \nu$ and of the deviation of k from ± 1 , which a careful discussion of the observations furnishes, represent fully whatever the observations really indicate about the inclination of the two planes and its direction.

The differentiation of the last equations gives

$$\begin{aligned}(s) dp &= \frac{k\rho}{(s)} \cdot \rho dv + \rho \sin v \cdot \cos(p-P) \cdot 57.3 dk \\ &\quad + \rho \sin v \cdot \sin(p-P) \cdot 57.3 d(\tan \nu) + (s) dP \\ 57.3 ds &= \left(k^2 - \frac{\sin(v+\nu) \cos(v+\nu)}{\sin v \cdot \cos v \cdot \cos^2 \nu} \right) \cdot \frac{\rho \sin v \cos v}{(s)} \cdot \rho dv + \frac{(s)}{\rho} \cdot 57.3 \cdot dp \\ &\quad + \rho \sin v \cdot \sin(p-P) \cdot 57.3 dk - \rho \sin v \cdot \cos(p-P) \cdot 57.3 d(\tan \nu) \\ &\quad + (s) \frac{57.3}{(a)} \cdot d(a).\end{aligned}$$

The equations of condition between variations of the computed coordinates and the corresponding variations of the elements of the orbit become accordingly:

$$\begin{aligned}(s) \delta p &= \frac{k}{(s)} \cdot \cos \phi [\delta \mu_0 + (t-t_0) \delta n] \\ &\quad + \frac{\rho}{(s)} \cdot (\sin v \cos \phi + \sin \epsilon) \cdot \delta \phi \\ &\quad + \rho \sin v \cdot \cos(p-P) \cdot \delta k \\ &\quad + \rho \sin v \cdot \sin(p-P) \cdot \delta(\tan \nu) \\ &\quad + (s) \cdot \delta P \\ 57.3 \delta s &= \left[\left(k^2 - \frac{\sin(v+\nu) \cos(v+\nu)}{\sin v \cdot \cos v \cdot \cos^2 \nu} \right) \frac{\cos v \cos \phi}{(s)} + \tan \phi \cdot \frac{(s)}{\rho} \right] \sin v \\ &\quad \quad \quad [\delta \mu_0 + (t-t_0) \delta n] \\ &\quad + \left[\left(k^2 - \frac{\sin(v+\nu) \cos(v+\nu)}{\sin v \cdot \cos v \cdot \cos^2 \nu} \right) (\sin v \cos \phi + \sin \epsilon) \cdot \frac{\rho \sin v}{(s)} \right. \\ &\quad \quad \quad \left. - \cos \phi \cdot \frac{(s)}{\rho} \right] \cos v \cdot \delta \phi \\ &\quad + \rho \sin v \cdot \sin(p-P) \cdot \delta k \\ &\quad - \rho \sin v \cdot \cos(p-P) \cdot \delta(\tan \nu) \\ &\quad + (s) \frac{57.3}{(a)} \cdot \delta(a)\end{aligned}$$

In case the eccentricity of the orbit is not large enough to allow the position-angle of the periastron to be safely treated as one of the elements, the most suitable new elements will be found by reckoning the orbital longitudes from the point of the orbit, for which $p = 0^\circ$, or where the orbit crosses the plane of the declination circle to the north of the chief star. If ω' is the orbital longitude of the periastron reckoned from this point, or $-\omega'$ the true anomaly of this point, the values of ω' and of the correspond-

ing $\sin \sigma$, say $\sin \sigma'$, are derived from the equations, which give p and $\sin \sigma$,

$$\sin \sigma \sin (p - \Omega) = \sin (v + \omega) \cos i$$

$$\sin \sigma \cos (p - \Omega) = \cos (v + \omega)$$

by putting

$$p = 0^\circ \text{ and for } v \text{ its special value } -\omega'.$$

Thus are found

$$\sin \sigma' \sin \Omega = \sin (\omega' - \omega) \cos i$$

$$\sin \sigma' \cos \Omega = \cos (\omega' - \omega)$$

$$\sin^2 \sigma' = 1 - \sin^2 i \sin (\omega' - \omega) \cos (\omega' - \omega).$$

The substitution of these values in the preceding or their equivalent equations

$$\sin \sigma \sin p = \sin (v + \omega) \cos i \cos \Omega + \cos (v + \omega) \sin \Omega$$

$$\sin \sigma \cos p = \cos (v + \omega) \cos \Omega - \sin (v + \omega) \cos i \sin \Omega$$

leads to the equations

$$\frac{\sin \sigma}{\sin \sigma'} \cdot \sin p = \sin (v + \omega') \cdot \frac{\cos i}{1 - \sin^2 i \cdot \sin^2 (\omega' - \omega)}$$

$$\frac{\sin \sigma}{\sin \sigma'} \cdot \cos p = \cos (v + \omega') + \sin (v + \omega') \cdot \frac{\sin^2 i \cdot \sin (\omega' - \omega) \cos (\omega' - \omega)}{1 - \sin^2 i \cdot \sin^2 (\omega' - \omega)}.$$

By the introduction of ω' and of

$$\frac{\cos i}{1 - \sin^2 i \cdot \sin^2 (\omega' - \omega)} = k' \text{ and } \frac{\sin^2 i \cdot \sin (\omega' - \omega) \cos (\omega' - \omega)}{1 - \sin^2 i \cdot \sin^2 (\omega' - \omega)} = \tan \nu',$$

as the new elements, which supplant Ω , ω , i , the equations for finding p and s become, if (σ) is written instead of

$$\frac{\sin \sigma}{\sin \sigma'}$$

and ω' instead of $a \sin \sigma'$ or $a \sqrt{1 - \sin^2 i \cdot \sin^2 (\omega' - \omega)}$,

$$(\sigma) \sin p = \sin (v + \omega') \cdot k'$$

$$(\sigma) \cos p = \cos (v + \omega') + \sin (v + \omega') \cdot \tan \nu' = \cos (v + \omega' - \nu') \sec \nu'$$

$$s = a' \rho (\sigma).$$

The differentiation of these equations gives

$$\rho (\sigma) dp = \frac{k'}{(\sigma)} \cdot \rho d(v + \omega') + \rho \sin (v + \omega') \cos p \cdot 57.3 \frac{dk'}{(\sigma)}$$

$$- \rho \sin (v + \omega') \sin p \cdot 57.3 \frac{d(\tan \nu')}{(\sigma)}$$

$$57.3 \frac{ds}{a'} = \left(k' - \frac{\sin (v + \omega' - \nu') \cos (v + \omega' - \nu')}{\sin (v + \omega') \cos (v + \omega') \cos^2 \nu'} \right) \cdot \frac{\sin (v + \omega') \cos (v + \omega')}{(\sigma)}$$

$$\rho d(v + \omega').$$

$$+ (\sigma) \cdot 57.3 \frac{d\rho}{(\sigma)} + \rho \sin (v + \omega') \sin p \cdot 57.3 \frac{dk'}{(\sigma)} + \rho \sin (v + \omega') \cos p \cdot 57.3 \frac{d(\tan \nu')}{(\sigma)}$$

$$+ \rho (\sigma) \cdot \frac{57.3}{a'} \cdot da'.$$

But

$$\rho d(v + \omega') = \frac{\cos \phi}{\rho} d(\mu + \omega') - (\cos v + \cos \epsilon \cos \phi + \tan \frac{1}{2} \phi) \cdot \tan \phi d\omega' \\ + (\sin v + \sin \epsilon \sec \phi) \cdot \cos \phi d\phi$$

and

$$57.3 d\rho = \tan \phi \sin v d(\mu + \omega') - \sin v \cdot \tan \phi d\omega' - \cos v \cdot \cos \phi d\phi.$$

Hence the equations of condition will be

$$\rho(\sigma) \delta p = + \frac{k' \cos \phi}{(\sigma) \rho} \cdot [\delta(\mu_0 + \omega') + (t - t_0) \delta n] \\ - \frac{k'}{(\sigma)} (\cos v + \cos \epsilon \cos \phi + \tan \frac{1}{2} \phi) \cdot 57.3 (\tan \phi + \delta e) \sin \delta \omega' \\ + \frac{k'}{(\sigma)} (\sin v + \sin \epsilon \sec \phi) \cdot 57.3 [(\tan \phi + \delta e) \cos \delta \omega' - \tan \phi] \\ + \rho \sin(v + \omega') \cos p \cdot 57.3 \delta k' \\ - \rho \sin(v + \omega') \sin p \cdot 57.3 \delta (\tan \nu')$$

and, if h is written instead of

$$k'^2 \sin(v + \omega') \cos(v + \omega') - \sin(v + \omega' - \nu') \cos(v + \omega' - \nu') \sec^2 \nu', \\ \frac{57.3}{a'} \delta s = + \left(\frac{h \cos \phi}{(\sigma) \rho} + (\sigma) \tan \phi \sin v \right) \cdot [\delta(\mu_0 + \omega') + (t - t_0) \delta n] \\ - \left[\frac{h}{(\sigma)} (\cos v + \cos \epsilon \cos \phi + \tan \frac{1}{2} \phi) + (\sigma) \sin v \right] \\ \cdot 57.3 (\tan \phi + \delta e) \sin \delta \omega' \\ + \left[\frac{h}{(\sigma)} (\sin v + \sin \epsilon \sec \phi) - (\sigma) \cos v \right] \cdot 57.3 [(\tan \phi + \delta e) \cos \delta \omega' - \tan \phi] \\ + \rho \sin(v + \omega') \sin p \cdot 57.3 \delta k' \\ + \rho \sin(v + \omega') \cos p \cdot 57.3 \delta (\tan \nu') \\ + \rho(\sigma) \cdot \frac{57.3}{a'} \cdot \delta a'.$$

If the assumed eccentricity is 0, and the orbital longitude of the comes, reckoned from the point of the orbit, for which $p = 0^\circ$, is called u' , the equations for finding p and s become

$$(\sigma) \sin p = \sin u' \cdot k' \\ (\sigma) \cos p = \cos u' + \sin u' \cdot \tan \nu' = \cos(u' - \nu') \cdot \sec \nu' \\ s = a' \cdot (\sigma)$$

and the equations between the variations of the coordinates and the variations of the elements :

$$(\sigma) \delta p = + \frac{k'}{(\sigma)} \cdot [\delta u'_0 + (t - t_0) \delta n] \\ - \frac{k'}{(\sigma)} \cdot \cos u' \cdot 2\phi \sin \omega' \\ + \frac{k'}{(\sigma)} \cdot \sin u' \cdot 2\phi \cos \omega' \\ + \sin u' \cdot \cos p \cdot 57.3 \delta k' \\ - \sin u' \cdot \sin p \cdot 57.3 \delta (\tan \nu')$$

and, if h' is written instead of

$$\begin{aligned}
 k'^2 &= \frac{\sin(u' - v') \cos(u' - v')}{\sin u' \cos u' \cdot \cos^2 v'}, \\
 \frac{57.3}{a'} \cdot \delta s &= + \frac{h'}{(\sigma)} \cdot \sin u' \cos u' \cdot [\delta u'_0 + (t - t_0) \delta n] \\
 &\quad - \left(\frac{h'}{(\sigma)} \cdot \cos^2 u' + \frac{1}{2}(\sigma) \right) \cdot \sin u' \cdot 2\phi \sin \omega' \\
 &\quad + \left(\frac{h'}{(\sigma)} \cdot \sin^2 u' - \frac{1}{2}(\sigma) \right) \cdot \cos u' \cdot 2\phi \cos \omega' \\
 &\quad + \sin u' \cdot \sin p \cdot 57.3 \delta k' \\
 &\quad + \sin u' \cdot \cos p \cdot 57.3 \delta (\tan v') \\
 &\quad + (\sigma) \cdot \frac{57.3}{a'} \cdot \delta a'.
 \end{aligned}$$

The geometrical meaning and the mutual relations of the various arcs and angles employed will be easily recognised with the help of a diagram constructed to indicate their significance on a sphere which has the chief star of the binary system in the centre. Let E denote the astral position of the Earth (in right ascension $\alpha + 180^\circ$ and declination $-\delta$); C that of the crossing point of the declination circle and of the circle representing the plane of projection; O that of the (positive) pole of the orbit, so that $EO = i$; Ω the position of the point of the orbit where it crosses the declination circle; Ω' that of the point where it crosses the plane of projection; P the position of the periastræ; S that of the satellite when its true anomaly is v . Further, let P_1 be the point where the arc EP or its prolongation meets the circle of projection; and P' and C' the points where the arcs OP, and OC or their prolongations cross the orbit.

The various arcs and angles are

$i = EO = O\Omega E$	$p = CES$
$\Omega = C\Omega = CE\Omega$	$P = CEP$
$\omega = \Omega P = \Omega OP$	$\sigma = ES$
$v = PS = POS$	$\sigma_0 = EP$
$\nu = PP = P'OP$	$\sigma' = E\Omega'$
$\omega' = \Omega'P = \Omega'OP$	$\tau = \Omega SE$
$\nu' = \Omega'C' = \Omega'OC'$	$OEC = 90^\circ - \Omega$
$\omega' - \omega = \Omega'\Omega = \Omega'O\Omega$	$POE = 90^\circ - \omega$

The arcs between any point of the orbit and O, and between any point of the circle of projection and E, are, of course, all $= 90^\circ$.

The values of $\omega, i, \Omega, \alpha$, corresponding to the values of $k, \tan \nu, P, (a)$, or of $h', \tan \nu', \omega', a'$ may be found by means of the formulæ

$$\gamma \sin 2\omega = 2 \tan \nu$$

$$\gamma' \sin 2(\omega' - \omega) = 2 \tan \nu'$$

$$\gamma \cos 2\omega = 1 - k^2 - \tan^2 \nu$$

$$\gamma' \cos 2(\omega' - \omega) = 1 - k'^2 - \tan^2 \nu'$$

$$\sin^2 i = \frac{\gamma}{1 + \gamma \sin^2 \omega}$$

$$\sin^2 i = \frac{\gamma'}{1 + \gamma' \sin^2 (\omega' - \omega)}$$

$$\sin \sigma_0 \sin (P - \Omega) = \sin \omega \cos i$$

$$\sin \sigma' \sin \Omega = \sin (\omega' - \omega) \cos i$$

$$\sin \sigma_0 \cos (P - \Omega) = \cos \omega$$

$$\sin \sigma' \cos \Omega = \cos (\omega' - \omega)$$

$$a = \frac{(a)}{\sin \sigma_0}$$

$$a = \frac{a'}{\sin \sigma'}$$

If $k \neq 1$ and $\tan \nu$ or $k' \neq 1$ and $\tan \nu'$ are of small amount, small variations of their values produce obviously large variations in the corresponding values of ω , i , Ω . The uncertainty in which semicircle ω , ω' , Ω are to be taken arises, of course, from the uncertainty which part of the true orbit is on the positive side of the plane of projection or in front of it. If the apparent motion of the comes in the direction of *increasing* or *decreasing* position-angles is to be treated as analogous to direct or retrograde motion of the bodies of our solar system in reference to the ecliptic, the Earth is at the positive pole of the plane of projection, and the ascending node Ω ought to be where the comes passes from the further or negative side of the plane of projection to the positive side or to that from which the observations are taken. The uncertainty whether the position-angle Ω belongs to the ascending or descending node must be allowed for in transferring the position of the orbit from the plane of projection to a plane parallel to the terrestrial equator, or to some other fundamental plane. If J denotes the inclination of the plane of the orbit to that of the equator, N the longitude or right ascension of the ascending node, and Q the orbital longitude of the periastron reckoned from N , the values of J , N , Q are derived from those of i , Ω , ω , and of a , δ , the right ascension and declination of the star, by means of the formulæ

$$\sin J \sin (\alpha - N) = \pm \sin \Omega \sin i \sin \delta + \cos i \cos \delta$$

$$\sin J \cos (\alpha - N) = \pm \cos \Omega \cos i$$

$$\sin J \sin (Q - \omega) = \pm \cos \Omega \cos \delta$$

$$\sin J \cos (Q - \omega) = \mp \sin \Omega \cos \delta \cos i - \sin \delta \sin i$$

$$\cos J = \pm \sin \Omega \cos \delta \sin i - \sin \delta \cos i$$

or by equivalent formulæ, the upper or lower signs being valid according as the value of δ refers to the ascending or descending node of the orbit on the plane of projection.

The apparent orbit of the comes may be laid down in the ordinary way by employing the semiaxes a and β of the apparent ellipse and their position-angle θ deduced from the elements. If Π is the position-angle of the centre of the apparent ellipse at

the place of the chief star, and S its distance, the values of Π , S , θ , α , β may be found by the formulæ

$$S \sin (\Pi - \Omega) = -ae \cdot \sin \omega \cos i$$

$$S \cos (\Pi - \Omega) = -ae \cdot \cos \omega$$

$$(\alpha^2 - \beta^2) \sin 2(\theta - \Omega) = S^2 \cdot \sin 2(\Pi - \Omega) = a^2 e^2 \cdot \sin 2\omega \cos i$$

$$(\alpha^2 - \beta^2) \cos 2(\theta - \Omega) = S^2 \cdot \cos 2(\Pi - \Omega) + a^2 \cos^2 \phi \cdot \sin^2 i$$

$$= a^2 e^2 \cdot \cos 2\omega + a^2 \sin^2 i (1 - e^2 \cos^2 \omega)$$

$$\alpha^2 + \beta^2 = S^2 + a^2 \cos^2 \phi (1 + \cos^2 i) = 2a^2 - a^2 e^2 + a^2 \sin^2 i (1 - e^2 \cos^2 \omega).$$

It will, however, be found more instructive to compute the apparent positions corresponding to a number of points of the true orbit, and to lay them down, together with the terminal points of the axes of the apparent ellipse, which may serve in drawing the latter. The eccentric anomalies ϵ in the true orbit which give the terminal points of the axes of the apparent orbit may be found from the equation

$$\tan 2\epsilon = \frac{-\sin 2\omega \cdot \cos \phi}{\cos 2\omega - e^2 \cos^2 \omega + e^2 \cdot \operatorname{cosec}^2 i};$$

or, in case k and $\tan \nu$ are the given elements, from

$$\tan 2\epsilon = \frac{2 \tan \nu \sec \phi}{k^2 + \tan^2 \nu - \sec^2 \phi};$$

or, if k' and $\tan \nu'$ are given, from

$$\tan 2\epsilon = -\cos \phi \cdot \frac{(k' \cos \nu')^2 \sin 2\omega' - \sin 2(\omega' - \nu')}{(k' \cos \nu')^2 \cos 2\omega' - \cos 2(\omega' - \nu') + e^2 [(k' \cos \nu')^2 \cos^2 \omega' - \sin^2(\omega' - \nu')]}.$$

The minima and maxima of the apparent distance of the two stars, and consequently the points of the greatest and least change of position-angle, may be found most conveniently by determining the true anomalies v , which satisfy the equation

$$\frac{\sin 2(v + \omega)}{\sin(v + \omega - \omega_1)} = 2e \cot g^2 i \cdot \frac{\cos \omega}{\cos \omega_1},$$

in which $\tan \omega_1 = \tan \omega \cdot \sec^2 i$, and which is to be solved indirectly.

This is a biquadratic equation, and, when developed, takes probably its simplest form if $\tan \frac{1}{2}(v + \omega)$ is made the unknown quantity. When written out in full the equation becomes

$$\begin{aligned} \tan^4 \frac{1}{2}(v + \omega) + \frac{2 \cos^2 i}{e \sin \omega} \cdot (e \cos \omega + \tan^2 i) \cdot \tan^3 \frac{1}{2}(v + \omega) \\ + \frac{2 \cos^2 i}{e \sin \omega} \cdot (e \cos \omega - \tan^2 i) \cdot \tan \frac{1}{2}(v + \omega) - 1 = 0, \end{aligned}$$

and the coefficients show that of the four roots of the equation

two are imaginary, or else that all four roots are real, according as the values of the two terms

$$e \cos \omega + \tan^2 i \text{ and } e \cos \omega - \tan^2 i$$

have the same or opposite signs.

This biquadratic equation is identical with the equation which determines the minima and maxima of the x ordinates of those instructive curves, the "ecliptical intersects" of the orbits of planets and comets, which, as I have explained in vol. xlv. of the *Monthly Notices*, will be found very serviceable in recognising the chief peculiarities and mutual relations of the orbits, and especially helpful in solving the problem of their proximities, provided, of course, that they are accompanied by the data necessary for the purpose. If there are no imaginary roots of the equation, so that there are two minima and maxima, the intersects become specially characteristic, as is the case with those of many cometary orbits, a few instances of which may be recognised on the reduced specimen plates published in vol. xlv.

If, instead of ω and i , k and $\tan \nu$ are the given elements, the equation for finding the true anomalies v , which furnish the points of min. and max. distance from the chief star in the apparent orbit, will be

$$0 = (k^2 + \tan^2 \nu - 1) \sin 2v - 2 \tan \nu \cos 2v + 2e[(k^2 + \tan^2 \nu) \sin v - \tan \nu \cos v];$$

$$\text{or, putting } g \sin G = -2 \tan \nu,$$

$$g \cos G = k^2 + \tan^2 \nu - 1,$$

$$h \sin H = -\tan \nu,$$

$$h \cos H = k^2 + \tan^2 \nu,$$

$$\frac{\sin (2v + G)}{\sin (v + H)} = -2e \cdot \frac{h}{g},$$

which is to be solved indirectly.

If ω' , k' , $\tan \nu'$ are the given elements, the corresponding formulæ are

$$g' \sin G' = 2 \tan \nu',$$

$$g' \cos G' = k'^2 + \tan^2 \nu' - 1,$$

$$h' \sin H' = -\sin (\omega' - \nu') \sec \nu',$$

$$h' \cos H' = k'^2 \cos \omega' - \sin \nu' \cdot \sin (\omega' - \nu'),$$

$$\frac{\sin [2(v + \omega') + G']}{\sin (v + \omega' + H')} = -2e \cdot \frac{h'}{g'}.$$

A special case still requires to be considered—the case in which one of the components of a binary system is invisible or unobserved, so that the orbit of the visible component round the centre of gravity of the system has to be determined from its observed right ascensions and declinations referred to those of other stars. The prospect of a fair determination must remain unpromising if the observations do not extend at

least over a full revolution, so that an approximate value of the period, or of the annual motion n , may be inferred with some confidence. If $n, e, \mu_0, \omega', a', k', \nu'$ are the seven elements of the orbit, the rectangular coordinates of the visible star (in right ascension α and declination δ) referred to the centre of gravity (in right ascension A and declination D) and to the circle of declination, are given by the equations

$$\begin{aligned} 15 \cos \delta (\alpha - A) &= s \sin p = a' k' \cdot \rho \sin (v + \omega'). \\ \delta - D &= s \cos p = a' \sec \nu' \cdot \rho \cos (v + \omega' - \nu'). \end{aligned}$$

The values of α and δ are therefore

$$\begin{aligned} \alpha &= A + \frac{a' k'}{15 \cos \delta} \cdot \rho \sin (v + \omega') \\ \delta &= D + a' \sec \nu' \cdot \rho \cos (v + \omega' - \nu'). \end{aligned}$$

Introducing the eccentric anomaly ϵ , instead of the true anomaly v , and putting

$$\begin{aligned} \kappa_1 \sin \omega_1 &= a' k' \cdot \sin \omega' \\ \kappa_1 \cos \omega_1 &= a' k' \cdot \cos \omega' \cos \phi \\ \kappa^* &= \frac{\kappa_1}{15 \cos \delta} \end{aligned}$$

and

$$\begin{aligned} \kappa_2 \sin \omega_2 &= a' \sec \nu' \cdot \sin (\omega' - \nu') \cos \phi \\ \kappa_2 \cos \omega_2 &= a' \sec \nu' \cdot \cos (\omega' - \nu'), \end{aligned}$$

the values of α and δ become

$$\begin{aligned} \alpha &= A - e \cdot \kappa^* \sin \omega_1 + \kappa^* \cdot \sin (\epsilon + \omega_1) \\ \delta &= D - e \cdot \kappa_2 \cos \omega_2 + \kappa_2 \cdot \cos (\epsilon + \omega_2), \end{aligned}$$

and show that of the seven elements or functions of elements of the orbit only five ($n, \mu_0, e; \kappa^* \sin \omega_1, \kappa^* \cos \omega_1$) can be determined from observed right ascensions alone, and five ($n, \mu_0, e; \kappa_2 \sin \omega_2, \kappa_2 \cos \omega_2$) from declinations alone.

The first approximate values of the unknown quantities may be got by deducing from the observations the maxima and minima of the rectangular coordinates, with the times corresponding to them, and also the times when the coordinates, in reference to some approximate values of A and D , are 0. If, in the case of observed right ascensions, τ and τ_1 are these latter times, and θ and θ_1 the times of max. and min. of $\alpha - A$, approximate values of the unknown quantities are derived from

$$\begin{aligned} 2e^\circ \sin \omega_1 &= 180^\circ - (\tau_1 - \tau) n \\ 2e^\circ \cos \omega_1 &= (\theta_1 - \theta) n - 180^\circ \\ \text{max.} - \text{min.} &= 2\kappa^* \\ \text{max.} + \text{min.} &= 2(\delta A - e \cdot \kappa^* \sin \omega_1) = 2e^\circ, \end{aligned}$$

and the mean anomaly at the time τ will be

$$= -\omega_1 + e^\circ \sin \omega_1.$$

If, in the case of observed declinations, θ' and θ'_1 are the times of the max. and min. of $\delta - D$, and τ' and τ'_1 the times when the difference is 0, so that the four times follow in the order θ' , τ' , θ'_1 , τ'_1 , approximate values of the unknown quantities are got from

$$2e^\circ \sin \omega_2 = 180^\circ - (\theta'_1 - \theta') n$$

$$2e^\circ \cos \omega_2 = (\tau'_1 - \tau') n - 180^\circ$$

$$\text{max.}' - \text{min.}' = 2\kappa_2$$

$$\text{max.}' + \text{min.}' = 2(\delta D - e \cdot \kappa_2 \cos \omega_2) = 2c_2$$

and the mean anomaly at the time τ' will be

$$= 90^\circ - \omega_2 - e^\circ \cos \omega_2.$$

As the observed right ascensions alone leave it uncertain whether k' and consequently κ^s is positive or negative, proper circumspection must be exercised to settle the point with the help of the observations in declination; and, if required, 180° must be added to the deduced value of ω_1 , so that the longitudes in the orbit may be reckoned from the point where the orbit crosses the declination circle on the north side of the centre of gravity.

The formulæ for correcting assumed approximate values of the elements or functions of elements are, if the observations in both coordinates are treated separately:

$$\begin{aligned} \delta(\alpha - A) = & + \frac{\cos(\epsilon + \omega_1)}{1 - e \cos \epsilon} \cdot \frac{\kappa^s}{57.3} [\delta\mu_0 + (t - t_0)\delta n] \\ & + \frac{\cos(\epsilon + \omega_1)}{1 - e \cos \epsilon} \cdot \sin \epsilon \cdot \kappa^s \delta e \\ & + \cos \epsilon \cdot \delta(\kappa^s \sin \omega_1) \\ & + \sin \epsilon \cdot \delta(\kappa^s \cos \omega_1) + \delta c^s \dots \\ \delta(\delta - D) = & - \frac{\sin(\epsilon + \omega_2)}{1 - e \cos \epsilon} \cdot \frac{\kappa_2}{57.3} [\delta\mu_0 + (t - t_0)\delta n] \\ & - \frac{\sin(\epsilon + \omega_2)}{1 - e \cos \epsilon} \cdot \kappa_2 \delta e \\ & - \sin \epsilon \cdot \delta(\kappa_2 \sin \omega_2) \\ & + \cos \epsilon \cdot \delta(\kappa_2 \cos \omega_2) + \delta c_2 \dots \end{aligned}$$

The two series of results have three unknown quantities, $\delta\mu_0$, δn , δe , in common, the most probable values of which must be found by properly combining the equations of the two series.

From the values of the other quantities are found

$$a'k' \cdot \sin \omega' = 15 \cos \delta \cdot \kappa^s \sin \omega_1$$

$$a'k' \cdot \cos \omega' = 15 \cos \delta \cdot \kappa^s \cos \omega_1 \cdot \sec \phi$$

and

$$a' \sec \nu' \cdot \sin(\omega' - \nu') = \kappa_2 \sin \omega_2 \cdot \sec \phi$$

$$a' \sec \nu' \cdot \cos(\omega' - \nu') = \kappa_2 \cos \omega_2.$$

If the eccentricity of the orbit is not large enough to allow $\delta\mu_0$ to be made directly one of the unknown quantities, and it is preferred to treat ω' , a' , k' , $\tan \nu'$ directly as the elements, and to determine the coordinates by

$$\begin{aligned} 15 \cos \delta \cdot (\alpha - A) &= x = a'k' \cdot \rho \sin(v + \omega') \\ \delta - D &= y = a' \cdot \rho \cos(v + \omega') + a' \cdot \rho \sin(v + \omega') \cdot \tan \nu' \\ &= a' \sec \nu' \cdot \rho \cos(v + \omega' - \nu'), \end{aligned}$$

the equations of condition between the differences of the observed and computed coordinates and the corresponding variations of the elements become

$$\begin{aligned} \delta x &= + [\cos(v + \omega') + e \cos \omega'] \cdot k' \cdot \frac{\rho' \sec \phi}{57.3} [\delta(\mu_0 + \omega') + (t - t_0) \delta \mu] \\ &\quad - [\cos(v + \omega')(\cos \epsilon \cdot \cos \phi + \tan \frac{1}{2} \phi) + \cos \omega'] \cdot k' \cdot a' (\tan \phi + \delta e) \sin \delta \omega' \\ &\quad + [\cos(v + \omega') \sin \epsilon - \sin \omega' \cos \phi] \cdot k' \cdot a' [(\tan \phi + \delta e) \cos \delta \omega' - \tan \phi] \\ &\quad + \frac{\pi}{a'k'} \cdot \delta(a'k') + 15 \cos \delta \cdot \delta A \dots \\ \delta y &= - [\sin(v + \omega' - \nu') + e \sin(\omega' - \nu')] \sec \nu' \cdot \frac{\rho' \sec \phi}{57.3} [\delta(\mu_0 + \omega') + (t - t_0) \delta \mu] \\ &\quad + [\sin(v + \omega' - \nu')(\cos \epsilon \cdot \cos \phi + \tan \frac{1}{2} \phi) + \sin(\omega' - \nu')] \cdot \sec \nu' \\ &\quad \cdot a' (\tan \phi + \delta e) \sin \delta \omega' \\ &\quad - [\sin(v + \omega' - \nu') \sin \epsilon + \cos(\omega' - \nu') \cos \phi] \cdot \sec \nu' \\ &\quad \cdot a' [(\tan \phi + \delta e) \cos \delta \omega' - \tan \phi] \\ &\quad + \rho \sin(v + \omega') \cdot a' \delta(\tan \nu') \\ &\quad + \frac{\eta}{a'} \cdot \delta a' + \delta D \dots \end{aligned}$$

from which the most probable values of the corrections are to be deduced. The elements ω , i , . . . are then found by the formulæ previously given.

Observations of Nova Cygni, of some of the Planets, and of Comet Barnard, made at Mr. Wigglesworth's Observatory with the 15.5-inch Cooke Equatorial. By J. G. Lohse.

Nova Cygni.

1885, Sept. 1.—*Nova Cygni* is of the same brightness as the small star of the 15th magnitude north preceding of it. No change in the brightness of the other stars, which were all seen, could be made out.

Oct. 3.—*Nova Cygni* was examined with a magnifying power of 260. It has become a little brighter, and is only 0.3 mag.

fainter than the stars Nos. 68 * and 73. The star No. 68 is a little brighter than No. 73, but the difference is scarcely 0.1 mag. *Nova Cygni* is not so well defined as the comparison stars, and is certainly surrounded by nebulosity. Attempts were made to see *Nova Cygni* with a McClean prism held in front of the eyepiece, but no trace of light could be recognised. The spectrum of the other three stars, forming with *Nova* a trapezium, could be seen without much difficulty, especially that of the 11th magnitude star No. 60.

Oct. 7.—*Nova Cygni* is of a bluish colour and surrounded by nebulosity. It is more than double as bright as the star No. 50, and about of the same brightness with Nos. 68 and 73. No. 68 is a little brighter than No. 73.

Oct. 26.—*Nova Cygni* was examined with magnifying powers of 330 and 130. It is decidedly surrounded by nebulosity, and about 0.3 mag. fainter than the stars Nos. 68 and 73. No. 73 is nearly 0.1 mag. brighter than No. 68. No. 50 was very well seen, but it has not half the light of *Nova Cygni*.

Dec. 1.—*Nova Cygni* is 0.3 magnitude smaller than stars Nos. 68 and 73. Definition poor.

1886, May 1.—*Nova Cygni* is of the 14.5 magnitude. No change amongst the neighbouring stars was noticed.

July 5.—*Nova Cygni* is of the 14th magnitude, and nebulous in appearance.

July 22.—*Nova Cygni* is equal in brightness to star No. 73, and 0.2 mag. fainter than No. 68. *Nova* appears nebulous. The 15th mag. companion of *Nova* was also seen.

Aug. 2.—*Nova Cygni* is equal in brightness to stars Nos. 68 and 73. The 15th mag. star near it was very well seen.

The estimations indicate a small increase in the brightness of *Nova* during October, and it seems that one of the comparison stars is variable to a very small extent.

Venus.

On January 2 and February 3, 1886, the dark part of *Venus* was distinctly seen by Mr. Wigglesworth and Mr. Lohse; it is of a gray colour, except near the terminator, where the secondary spectrum causes it to appear blue, and compared with the bright part of *Venus* it looks very much smaller. On January 2, from 5^h 15^m to 5^h 35^m G.M.T., when the definition was very good, the upper or south horn appeared rounded while the lower one was quite sharp. In prolongation of the lower horn, but perfectly separated from it, was a bright narrow line of light about $\frac{1}{10}$ of the diameter of *Venus* in length. A similar phenomenon is often presented by the mountains of the Moon near the south horn, which appear along the edge as a detached irregular line of light as long as the summits only are illuminated.

* *Copernicus*, vol. ii. p. 118.

Mars.

During the opposition of 1886 the white spots near the poles of *Mars* were very small. On April 23, 10^h 38^m G.M.T., both white spots were very well seen; the northern spot was brighter than the southern one, but in size they were about equal. The diameter of the spots was estimated to be $\frac{3}{4}''$. On April 26, 9^h G.M.T., the northern white spot was very well seen; it seemed larger than on April 23, but the southern white spot was certainly not visible at the time.

Saturn.

1885, Nov. 17.—The globe extends at the top beyond Cassini's division, and encroaches on the outer ring to the extent of a quarter to one-third of the breadth of the latter. Encke's division was seen in the ansæ four-tenths of the breadth of the outer ring from Cassini's division.

Nov. 18.—Encke's division was seen in the same position, and the globe's shadow on the crape ring was noticed distinctly. Definition good.

Dec. 2, 13^h 45^m G.M.T.—*Mimas* was seen distinctly in elongation on the following side. *Saturn* was not artificially obscured at the time nor moved out of the field. Encke's division was plainly seen in both ansæ nearly in the middle of the ring.

Dec. 26.—There is a northern and a southern belt and a dark polar cap on *Saturn*. The brown copper colour of the globe was very strongly shown. Encke's division was seen, and dark parallel lines on the inner side of the ansæ of the inner bright ring.

1886, Jan. 2.—The polar cap is darker than the south belt.

Feb. 3.—Encke's division was very well seen by Mr. Wigglesworth and Mr. Lohse.

March 25.—*Saturn* was very well seen. Encke's division could be traced very nearly right round, when the definition was at its best. The division is two-fifths from the outer edge and three-fifths from Cassini's division. At 8^h 2^m G.M.T., Mr. Wigglesworth saw *Mimas* in southern conjunction. Mr. Lohse tried to see it as well, but could not do so with certainty. The southern and northern dark belts showed very well, and the globe was plainly visible through the crape ring. Mr. Wigglesworth observed a faint narrow dark marking in the middle of the bright equatorial zone.

The dimensions of *Saturn* were measured 1885, Dec. 26, and 1886, Jan. 2, and the following are the mean results reduced to mean distance ($\log = 0.97950$):

Exterior diameter of outer ring (A)	40 ^{''} 95
Interior " " "	35 ^{''} 53
Exterior diameter of inner ring (B)	34 ^{''} 38
Interior " " "	25 ^{''} 55
" " of crape ring (C)	20 ^{''} 97
Equatorial " of globe	18 ^{''} 57

On Jan. 2 the following quantities were also measured, and reduced to mean distance give

Polar diameter of outer ring (A)	19 ^{''} 06
Distance of south pole from south limb	1 ^{''} 81
" " belt " north "	8 ^{''} 14

Considering the equator coincident with the plane of the rings, the south belt would be situated in 25[°]·8 south kronocentric latitude.

Neptune.

The following observations of the satellite of *Neptune* were made. The satellite was always very faint; it was estimated to be of the 14th magnitude.

Date.	Greenwich M. T.	Position.	Distance.
	h m	°	
1885, Dec. 2	12 48	41 [°] 71	17 ^{''} 62
1886, Nov. 2	14 19 [·] 5	40 [°] 78	16 ^{''} 71
4	14 49	247 [°] 88	14 ^{''} 14

Observations of Comet Barnard made at Mr. Wigglesworth's Observatory with the 15.5-inch Cooke Equatorial.

Date. 1887.	Greenwich Mean Time.		$\Delta\alpha$	$\delta - \star$	$\Delta\delta$	α		δ	Comparisons.
	h	m s	m s			h	m s		
May 20	11	21 23	+1 8.18 $\pm$.09		+5 51.6 $\pm$.8	15	23 50.68	-25 6' 59.7"	6, 6
21	12	22 42	- 42.55 $\pm$.09		- 59.2 $\pm$.8	15	25 42.86	-25 25 58.7	4, 4
29	12	43 41	-5 43.99 $\pm$.10		+9 50.6 $\pm$ 1.2	15	41 4.60	-19 39 51.6	3, 3

Adopted Mean Places of Comparison Stars for 1887.0.

Date	α		Reduction.	δ	Reduction.	Authority.
	h	m s	s			
May 20	15	22 40.33	+2.17	-26 12 49.9	-1.4	Star connected with Yarnall 6419
21	15	26 23.26	+2.15	-25 24 58.3	-1.2	" " " 6405
29	15	46 46.47	+2.12	-19 49 42.3	+0.1	Yarnall 6543

The comet has a nucleus, but is faint and small. The observations are corrected for refraction.

Mr. Wigglesworth's Observatory, Scarborough:
1887, June 8.

The Solar Corona, as shown in Photographs taken during Total Eclipses. By W. H. Wesley.

(Communicated by the Secretaries.)

Having had occasion to make a very minute examination of the negatives taken during several of the recent solar eclipses, I have thought that it might be of interest to give an account of some of the prominent features of the photographic corona in the different years. I do not attempt to propound any theories, and shall only mention some of the current hypotheses with a view of showing how far they appear to be supported or contradicted by the photographic records.

Mr. Ranyard in the eclipse volume of the *Memoirs* has so fully discussed the photographs taken previously to 1878, that in most cases it will only be necessary very briefly to allude to them.

One of the most striking features in the corona of almost all the years under examination is the existence of a more or less well-marked polar rift, roughly, but perhaps never exactly, corresponding with the Sun's axis of rotation, to which it appears sometimes inclined as much as 30° . In most cases this rift is shown at both poles, but sometimes at one only; in 1882 it does not appear at all. The northern and southern rifts are seldom strictly opposite to one another, so that a line drawn through them does not pass through the centre of the Sun. The polar rifts are generally filled with shorter, straighter, and more radial rays, with a background of less density than in other parts of the corona.

On either side of the polar rift there usually appears a somewhat conical mass, composed of rays curving towards each other, forming groups of what Mr. Ranyard has appropriately called "synclinal structure," which give the quadrilateral or cruciform appearance frequently shown in corona drawings. They mostly seem to be situated over the zones of maximum sunspot activity, and have frequently greater extension than other parts of the corona.

Eclipse of 1851, July 28.

Dr. Busch's daguerreotype is remarkable as the first instance of a successful photograph of the corona. It shows the general form to a height nowhere much exceeding $\frac{1}{4}$ of a solar diameter. The corona is symmetrical and of hexagonal form, with a well-marked rift not far from the north and south poles, the southern rift being much the broader. On either side of these rifts are indications of synclinal masses; there are also similar masses in the equatorial regions fairly corresponding on each side. The orientation of the plate is rather uncertain. Wolf gives 64.2 as the relative number of sunspots for July 1851.



Eclipse of 1860, July 18.

In the photographs taken at Desierto de las Palmas, of which I have only seen positive copies, there is shown a very broad rift towards the south pole, and a less marked one on the north. The character of the synclinal groups is not clearly marked. The corona is fairly symmetrical about a line not much inclined from the Sun's axis. Wolf's relative number of sunspots is 94.9.

Eclipse of 1869, August 7.

I have not seen the original negatives of the photographs taken at Shelbyville, which are the only ones which show any considerable extent of corona. The northern and southern polar rifts are clearly marked and very broad. The bases of the four synclinal groups can also be clearly made out, especially that in the north-west quadrant. The general axis of symmetry is slightly inclined to the north-west and south-east of the Sun's axis. Wolf's relative number of sunspots is 77.6.



Eclipse of 1870, Dec. 22.

Mr. Brothers's negative, taken at Syracuse, shows a great extent of corona, reaching in some parts quite 40' from the limb.

The general outline is somewhat circular, with a quadrilateral area of greater brightness, brighter on the western side. The northern polar rift is broad and ill-defined; to the east of the south pole is a much narrower and more sharply defined rift, easily traceable to the limb. To the east and west of this are other rifts, and there is structure evidently synclinal to the north-west; otherwise the photograph shows but little detail. The general axis of symmetry appears inclined to the north-west and south-east of the Sun's axis as much as 20° , but the orientation is not very certain. The eclipse occurred at a period of great solar activity, Wolf's relative monthly number being 135.4



Eclipse of 1871, Dec. 12.

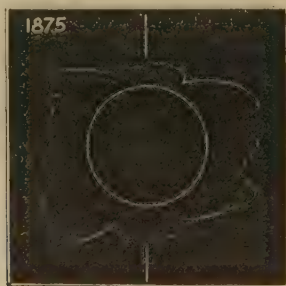
Lord Lindsay's and Col. Tennant's excellent series of negatives show a corona remarkably symmetrical, about a line inclined about 10° to the north-west and south-east of the Sun's axis. The northern and southern polar rifts are well defined, nearly opposite to one another, and very similar in character. The four synclinal groups are well marked, appearing to indicate zones of synclinal structure extending nearly from the pole to about 40° north and south latitude. These groups are generally separated from the equatorial portions by narrow definite rifts. The western margin of the south-east synclinal group shows a distinct tendency to double curvature—a form which reappears in 1883 and 1885. The extension is greatest in the equatorial regions, giving a somewhat hexagonal form to the corona. The great polar rifts are filled with short straight rays.

The greatest extent of the photographic corona does not exceed $27'$, but the minuteness of the detail near the limb, which

with a strong transmitted light can be seen through the densest part of film, has never been equalled in any subsequent eclipse photograph. The remarkable feature of the lower structure is the prevalence of rays completely curving over, and of branching rays, somewhat resembling a frequent form of solar prominence. Few of these reach a height of more than 5' from the limb; above this height the rays are generally straight or more slightly curved.

It is impossible to be certain whether these lower details are really near the limb, or whether they are rays on the nearer or further parts of the corona, seen foreshortened. In the latter case, they could hardly be the extreme ends of coronal rays, as these invariably fade away so much towards their extremities that they would certainly be lost on the dense background. On the whole, the difference of character between the higher and the lower details lends great probability to the view that the latter are really near the limb. Mr. Ranyard considers that the more contorted character of these lower structures indicates the existence of a resisting atmosphere in the lower part of the corona. It seems evident, at least, that many of the curvatures of the coronal rays could not be caused by gravity alone. Still when we consider what an intricate mass of crossing and interlacing rays must be produced by perspective as we approach the limb, we must feel that the question cannot be decided with certainty.

The eclipse occurred at a time of somewhat less solar activity than that of the previous year, Wolf's relative monthly number being 98.0.

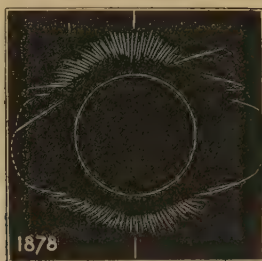


Eclipse of 1875, April 6.

The small size of the photographs taken by Dr. Schuster renders it impossible to make out more than the general character of the corona, and from the same cause the orientation is not very accurately determined. The corona is somewhat symmetrical about a line nearly coinciding with the Sun's axis, the northern and southern polar rifts being very broad and well marked. Four synclinal groups are plainly seen, their axes making angles of more than 45° with the Sun's axis. The polar rifts are filled up, but not to a great height, the polar extension of the corona being only about half the equatorial, where

the greatest height is nearly a solar diameter. The half of the corona lying to the east of the axis is decidedly larger than that to the west, so that the nearly straight lines which bound the corona north and south converge towards the west. Dr. Schuster draws attention to the remarkable similarity between this corona and that of 1874, of which no photographs were taken. He thinks this similarity extends to the irregularity in the symmetry just mentioned; but the want of accordance between the drawings made in 1874 renders this uncertain.

Notwithstanding this general resemblance, the solar activity, as indicated by the sunspots, was less than half as great as in the previous year, Wolf's relative number for April 1874 being 49.1, and for April 1875, 20.5.



Eclipse of 1878, July 29.

The photographs which I have examined are two negatives by Mr. Ranyard, made at Denver, and a series of 9 positive copies on glass of the photographs taken by Professor Harkness and Mr. Rogers at Creston and La Junta. The exposures of Mr. Ranyard's plates were so short that they show but a small extent of corona. A drawing combining the detail of the Creston and La Junta negatives, and showing a further extension of the equatorial rays, from a smaller photograph by Mr. Peers, is given in the "Appendix to the Washington Observations" for 1876. On comparing this drawing with the positives, it does not seem very satisfactory. I can make out as much or more detail on the positives as on the drawing (except the equatorial extension), and no doubt much more would be seen on the original negatives.

The corona belongs to the same type as those of 1874 and 1875. The equatorial extension greatly exceeds the polar, and both the northern and southern rifts are widely opened, so that their eastern and western boundaries form nearly straight lines tangential to the limb. The northern and southern synclinal groups are so much depressed towards the equator that they appear to coalesce into one great mass, occupying the whole equatorial region. The rifts are filled with fine rays, straight, and nearly radial in the centre of the rift, and becoming more and more curved towards its boundaries. In one rift there are as many as 20 separate rays, remarkably uniform in length and

distance apart, never branching or crossing. The two rifts are almost identical in character, but are not opposite each other; the northern rift having its general axis inclined about 15° towards the east from the Sun's axis, and the southern being more symmetrical with it.

The great equatorial extensions, of which the bases only are visible in the positives, are very symmetrical in detail, but the western mass is the broader, reaching further both to the north and south. These great masses are broadest near the limb, and gradually become narrower, so that their northern and southern boundaries would meet in a point about 2 diameters from the limb on the western side, and rather less on the eastern. These equatorial extensions were, however, observed by Newcomb, Langley, and others, to reach to a distance of at least 12 diameters. They must have been very faint, as in the American drawing, combined from various negatives, they do not extend more than a diameter.

It is a remarkable peculiarity, which I have observed in no other corona, that while at the poles it is split up into a great number of fine rays, the equatorial extensions are broad smooth masses, showing scarcely any detail, even at their extreme edges.

The eclipse occurred at a time of decidedly low solar activity, Wolf's relative number being only 3.3.



Eclipse of 1882, May 17.

The negatives taken by Dr. Schuster show a large extent of corona, reaching in several places a height of a solar diameter, one straight ray in the south-west extending as far as $1\frac{1}{4}$ diameter. The corona presents none of the features which characterised those of 1874, 1875, and 1878. Although very irregular in detail, it is approximately circular in form, and is entirely without that great difference between the polar and equatorial extensions which had been so striking in the three

last eclipses. At the same time it shows none of that symmetry about a line not very far from the Sun's axis that had been more or less apparent in most previously photographed coronas, and especially in that of 1871. This absence of an axis of symmetry and of polar rifts is its most striking feature. There are groups of synclinal structure, but they are not of a very definite character, and are quite irregularly placed. The solar axis does not pass through the line of least extension, as is almost always the case. The only approach to an axis of symmetry seems to be about a line nearly at right angles with the Sun's axis. The orientation was, however, very carefully made, and in Dr. Schuster's opinion is not more than half a degree in error: it nearly agrees with that adopted by Professor Tacchini.

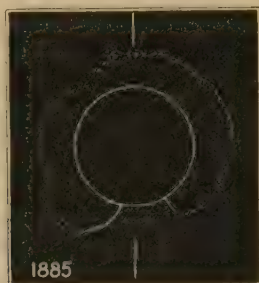
The rays are rather more frequently straight than curved, and there is only one instance of a ray completely curving over: this is in the south-east; it reaches a height of about 12' from the limb. Beneath it are two rays—the only ones showing any traces of a branching structure. There are distinct rifts on the western side, reaching to the limb; but they are more filled up with coronal matter than those of 1871. The rays are in all directions, from radial to tangential, and there are several cases of rays crossing each other, but no clear case of a ray of double curvature. The lower details of the corona are less distinct than in 1871; but this may be due to the great density of the film near the limb, which is common to all dry-plate negatives. The definition of the outer portions is extremely fine. I cannot see any evidence of the distinction between an outer and inner corona, which Dr. Schuster thinks the photographs show. Wolf's relative monthly number of sunspots is 64.5; a remarkable outburst had occurred during the preceding month, for which the number was 95.8.



Eclipse of 1883, May 6.

Successful photographs were taken by M. Janssen, and also by Messrs. Lawrance and Woods. The most prominent feature is an unusually well-marked rift, partly filled with short straight rays, near the north pole of the Sun's axis, from which the general axis of the rift is inclined at an angle of about 30° to the east. On each side of this rift are most characteristic groups of synclinal structure, whose bases meet at the limb: the easternmost shows a double curvature on both sides, but on the western edge this appearance seems caused by the superposition of different rays. There seems no regularity in the arrangement of the rays in the rest of the corona, nor any rift in the south, corresponding to that in the north. The general outline of the corona is somewhat circular, but the two synclinal groups extend farther than any other part. In M. Janssen's long-exposed plate, one of these groups extends nearly as far as two solar diameters, which is the greatest extension shown by any corona photograph. Indeed, M. Janssen says that it is much greater than it appeared to the eye in his telescope.

The solar activity was rapidly decreasing, Wolf's relative monthly number of sunspots being 32.1 .

*Eclipse of 1885, September 8.*

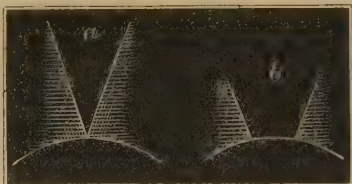
Several photographs were taken of this eclipse, but the weather was generally unfavourable, and few show much detail. The most marked feature is the southern rift, which is broad and well marked, with clear indications of straight rays filling it. The only distinctly synclinal group is to the south-east; its axis makes an angle of about 45° with the Sun's axis, and its extension is greater than any other part of the corona. The western edge of this group presents a double curvature. The other parts of the corona are very irregular, and there does not appear to be any distinct rift on the north corresponding with the southern rift. There is a marked broad depression in the corona, about 35° to the east of the north point of the axis. This depression, and the southern rift, appear to divide the corona into two very unequal parts, the western one being much the greater.

The solar activity, as shown by the sunspots, was diminish-

ing; Wolf's relative monthly number being 83.7 for the month of June, and 39.6 for September.

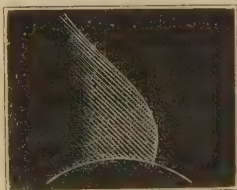
The results of the observations of the eclipses of 1883 and 1886 are in course of publication by the Royal Society, and I have not their permission to describe the details of the corona of these years.

Since the corona entirely surrounds the Sun, and is not a mere fringe as it necessarily seems to the eye, its appearance is greatly modified by perspective. The groups of synclinal structure, when they occur somewhat symmetrically on opposite sides of the Sun, must evidently be regarded as zones of curving rays, the shorter and straighter rays filling the polar rifts, being probably the rays on the nearer or further parts of the synclinal zone seen foreshortened. A curved tangential ray, if curved or inclined in the line of sight, will appear straight and radial but shortened. On the other hand, foreshortening may greatly increase the apparent curvature of a ray. The true point on the Sun from which a ray springs is not seen unless it springs from the limb. The polar rifts must be greatly modified in appearance if they are inclined in the line of sight. It is obvious that a rift which would resemble *a* if actually on the limb would be more like *b* if its axis were directed towards or from the Earth.



The greater apparent density of the corona near the limb must, of course, be largely due to its greater thickness. It is only at the extreme outer limits of the corona that we can see the true character of its rays, as it is only there that they are unaffected by perspective or superposition.

A large proportion of the coronal rays are curved, the curves being of various kinds. It frequently occurs, at the edges of the synclinal groups, that a ray which appears to spring from the limb in a nearly radial direction is abruptly curved, and then straightened, so as to become almost tangential: this is a most characteristic form of coronal ray. Sometimes after it has attained a considerable height it is slightly curved in a contrary direction, as is well seen in 1871, 1883, and 1885.



Rays completely curving over and branching rays have been mentioned in the description of the corona of 1871, in which they are very numerous; but they are scarcely seen in any other eclipse. Possibly they occur as a rule only near the limb, which portion has never been so clearly shown as in the photographs of 1871.

Dr. Huggins suggests that the curved rays may be caused by matter blown upwards, rising with the smaller rotational velocity of the photosphere from which it started, and appearing to lag behind in its ascent.* But in this case we should expect the curves to be similar in direction and character in any part of the corona, while in fact there is no such regularity, which seems to show that the curvature cannot be the result of this cause alone.

The coronal rays are invariably brighter near the limb, and fade gradually away towards their extremities, where they are sometimes pointed and sometimes spreading. Sometimes they rise from a broad extended base, which character may be more frequent in reality, as the base would be hidden if the ray is not upon or near the limb.

The absolute brightness and extension of the corona during different eclipses cannot be ascertained from the photographs, as they have been taken with various instruments and exposures, and on plates of different degrees of sensitiveness. The earlier collodion photographs probably never showed half the visible corona, while the recent negatives taken on dry plates with long exposures may show more than is visible to the eye.

The coronal matter is very transparent, many rays crossing others which are seen through them.

Nothing that I have seen on the eclipse photographs seems to give the least countenance to any of the meteoric theories of the corona. Drawings such as that of Liais in 1858, representing the synclinal groups as symmetrical cones, would be readily interpreted as streams of meteors passing round the sun; and drawings like Gillman's in 1869, giving innumerable rays all truly radial, might indicate matter falling into the Sun. In the photographs, however, the cones are never symmetrical, and are shown to consist of many rays of various curvatures, while rays that are truly radial are quite exceptional. If the rays were meteor streams sweeping past the Sun we should expect to trace the same streams at opposite sides, while in fact there is no such exact correspondence, even in the most symmetrical corona of 1878.

The detailed structure of the corona seems quite conclusive evidence against Professor Hastings's theory that it is a diffraction phenomenon.

Whatever may be the true cause of the corona, it is impossible for one who has examined the photographs to resist the conclusion that in some way it proceeds from the Sun. The character of the curved rays—especially those which curve com-

* Bakërian Lecture, *Proc. Roy. Soc.*, vol. xxxix. p. 127.

pletely over—the invariably greater brightness of the corona as it approaches the limb, the broad base from which the rays sometimes spring, all seem capable of no other explanation.

Although many observers have spoken of movement of the coronal rays, and have recorded changes of form during totality, there is nothing in the photographs to show that changes of such magnitude as to be visible have taken place in so short a time. Photographs taken an hour apart in 1871 show no visible change, while the clearness of the details proves the appearance of movement to have been an illusion.

I am unable to see in the eclipse photographs any ground for the distinction often drawn between an “inner” and “outer” corona. The principal details can generally be traced down to the limb, and there does not seem any sudden falling-off of the light (except what is caused by occasional strongly curved or foreshortened rays), nor other indication of a want of continuity. It seems to be of the same character throughout. At the same time, it may be true that the lower structures are more frequently of a strongly curved or branching character.

There is no sign of any connection between the coronal rays and the solar prominences.

The only generalisation with regard to the form of the corona which has seemed well supported by the photographic evidence is that of Mr. Ranyard, that there is a connection between the general form of the corona and the solar activity as shown by the number of sunspots. The corona of a sunspot maximum has generally been somewhat symmetrical, with synclinal groups making angles of 45° or less with its general axis. The sunspot minimum coronas show polar rifts much more widely open, synclinal zones making larger angles with the axis, and being therefore more depressed toward the equatorial regions, in which there is usually greater extension. This generalisation is well borne out by the maximum coronas of 1870 and 1871 and the minimum coronas of 1867, 1874, 1875, and 1878. On the other hand, the eclipses of 1883, 1885, and 1886, do not strikingly confirm the theory. The eclipse of 1883, at a time of rapidly decreasing solar activity, shows all the characters of a sunspot maximum corona; the same in a somewhat less degree may be said of 1885 and 1886, at both of which times the solar activity was decreasing. Although the polar rifts were wide in 1886, there was no marked depression of the synclinal groups towards the equator, nor any great equatorial extension, although the relative number of sunspots for August 1886 was only 16.9. Striking, therefore, as the evidence in favour of the generalisation has been in many years, it still seems probable that the form of the corona is modified by other causes at present unknown to us.

It may be that the coronal axis (to use a convenient term) is always inclined at the same angle to the Sun's axis of rotation, and that the apparent changes in its inclination are caused by its being seen from different points of view. Before this question

can be answered, photographs must be taken at every total eclipse for many years to come. It will, above all, be necessary, however, that the utmost care be taken in the orientation of the plates, that there may not be the slightest doubt as to the position of the Sun's axis. Unfortunately, on several of the eclipse photographs there is great uncertainty on this most important point. It is preferable to take a series of photographs of the solar crescent (by stopping the clockwork in the usual way) both before and after totality, so as to guard against the danger of any slight shift of the instrument.

Sometimes a wire has been placed in the instrument for the purpose of orientation; but wherever this crosses the corona it interferes with the details, and is on that account a disadvantage. In 1886 two pointers were used, one on either side, beyond the limits of the corona; but there is a risk of these not being visible on the plates. If the plate perfectly fit the plate-holder there hardly seems any necessity for a wire.

To prevent mistakes in orientation the plan adopted by Mr. Davis in 1871 was an excellent one. Each of his plates had one corner cut off, corresponding with a small fixed block in one corner of the exposing frame, so that no doubt could afterwards arise as to the position of each plate when exposed.

In the reports of the observations it need hardly be said that the data from which the orientation is obtained should always be fully stated.

It is much to be wished that in future eclipses photographs could be taken which would show the lower details as clearly as the negatives of 1871; I am almost inclined to recommend collodion plates, such as were then employed. The excessive density of the corona near the limb in all the dry-plate negatives obscures the lower details, while the greater coarseness of the grain makes it impossible to use much magnifying power in their examination. At the same time, we ought not to forego the great advantage of the gelatine film in giving the full extension of the corona. It is to be hoped that by some improvement in the preparation of plates both these advantages may be combined.

In the meantime careful drawings would be of great utility if observers would, instead of vainly trying to give a general view of the entire corona, which is quite impossible in the short time at their disposal, restrict themselves to making as exact delineations as possible of the details in some portion only. The general appearance of the corona is admirably given in a good photograph; but this would be most usefully supplemented by detailed drawings of selected portions, especially of the structure near the limb, in which the photograph most frequently fails.

1887, June 9.

Physical Observations of Saturn in 1887.

By Thomas Gwyn Elger.

The following observations of the planet were made with an $8\frac{1}{2}$ -in. silver-on-glass reflector by Calver during the months of February, March, and April.

12th February, 9^h to 10^h. Good definition; East wind. Planet beautifully defined with a power of 350. *Rings*.—A. No trace of any division; outer border slightly darker than the remainder. B. Inner edge very dark. Ring gradually increasing in brightness to about midway between the interior and exterior borders. Outer half uniformly bright. C. Both ansæ extremely dark, hardly distinguishable except where it crosses the ball; here it is sufficiently transparent to allow the latter to be seen through it. *Belts*.—The broad equatorial belt is orange-yellow in colour, and sharply defined on its northern edge by a darker band of varying width. Its southern limits are marked by a much fainter band, the intervening space exhibiting a mottled appearance—due to the presence of light spots and markings. About midway between the bluish-grey polar cap and the equatorial zone there is a faint belt, but this region is very indistinct. *Shadow of ball*.—The *f* side of the sharply-defined shadow on B appears to be concave up to Cassini's division, where there is a well-marked notch, apparently coincident with the latter. South of this, on ring A, the shadow follows the curvature of the ball, and seems to be somewhat narrower than any portion of the shadow on ring B. The south limb of the ball is slightly within the outer edge of A.

16th February, 8^h to 9^h. Frosty; wind N.E. Definition variable—not so good as on the 12th. Powers used, 284, 350. *Rings*.—A. Is similar in colour to the polar cap—viz. greyish-blue. There is an evident though faint light line concentric with the ring about midway between the outer and inner edge, but rather nearer the former. It can be traced for some distance on both ansæ, but is more easily seen on the *p* side. B. The shading on this ring becomes gradually lighter from the inner edge to a point about $\frac{1}{4}$ th the apparent width of the belt from the outer edge, where it suddenly ceases, the remainder of the ring being uniformly bright. C. Dark, but distinct on *p* side. *f* ansa nearly indistinguishable. *Belts* less favourably seen than on the 12th.

21st February, 9^h to 9^h 30^m. Definition variable. Power used, 350. *Rings*.—A. No trace of any detail. B. The bright outer edge appears to be of the same tone, but slightly more brilliant than the central portion of the ball immediately north of the equatorial belt. C. Both ansæ very dusky—scarcely distinguishable, except here and there. *Belts*.—North border of equatorial belt sharply defined. Mottled surface evident. Polar and intermediate zone indistinct. *Shadow of ball*.—As on the 12th

25th February, 9^h to 9^h 30^m. Definition on the whole favourable. Power used, 350. *Rings*.—A. No detail seen; inner edge, adjoining Cassini's division, on *p* ansa somewhat darker than the general surface. B. As on the 21st. C. *p* ansa very obscure, in places as dark as the space between the ball and the ring system. Nothing abnormal was noted in connection with the *f* ansa, though at times the *nf* part of the ring seemed to be lighter than the remainder. *Belts*.—All badly defined.

26th February, 8^h 30^m to 9^h 30^m. Clear frosty night with good definition. Powers used, 284, 350. *Rings*.—A. No detail visible. B. Gradually increasing in brightness from the inner to the outer edge, which is bounded by a narrow zone of uniform brilliancy about equal in width to Cassini's division. C. With both eyepieces the *p* ansa exhibits on its inner border three or four large re-entering angles like the teeth of a saw, the intervening spaces being apparently as dark as that between the ball and the ring, and extending nearly to the outer edge of the ring. This appearance is confined to the western section of the ansa, there being nothing abnormal as regards the *sp* and *np* portion of it. The *f* ansa is dark but traceable. *Belts*.—Details well seen.

27th February, 9^h to 9^h 30^m. Definition variable. Powers used, 284, 350. *Rings*.—A. Light line visible for some distance on both ansæ, as on the 16th inst. Inner edge slightly darker than the rest of the surface. B. As on the previous evening. C. The indented edge of the *p* ansa cannot be made out, but the surface of the ring is unequally dark. At times of best definition two or three dark areas are noted upon it with both eyepieces.

28th February, 9^h to 9^h 30^m. Sky hazy. Good definition, affording some exquisite glimpses of the planet. Power used, 350. *Rings*.—A. Light streak seen on both ansæ, as on the 16th and 27th. C. Very dusky, only isolated areas of the *p* ansa visible. *Belts*.—Equatorial belt covered with ill-defined detail, and bounded on the north by a wide band, much darker than any other portion of the ruddy zone. Faint belt on the northern hemisphere visible near the east and west limb. The greater portion of it is hidden by the ring C, to which it is about equal in tone.

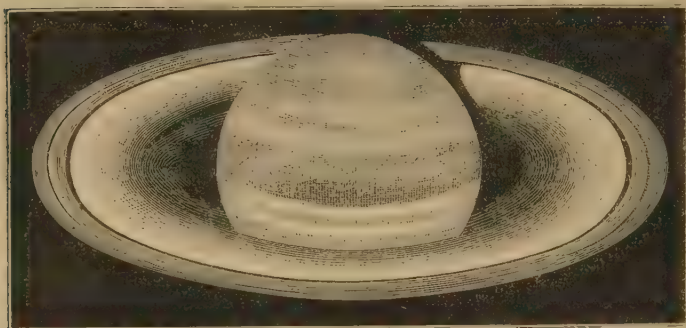
12th March, 8^h 30^m to 9^h 30^m. Definition variable. Wind E. Powers used, 284, 350. *Rings*.—A. No detail visible. C. *p* ansa is very evidently broken up into several areas of different degrees of darkness, so that, except a short section of it, *np*, it is impossible to recognise it as a ring surrounding the planet. The *f* ansa, on the contrary, is easily visible. *Belts*.—All fairly distinct. *Shadow of ball*.—The southern limb and outer edge of A are apparently coincident, and the shadow south of the well-marked notch at Cassini's division becomes gradually wider as it approaches the boundary of the ring.

13th March, 8^h 30^m to 9^h 15^m. Frosty; E. wind. Definition variable. Powers used, 284, 350. *Rings*.—A. A faint dark line, presumably Encke's division, seen on the widest part of both ansæ. B. Inner edge very obscure, ring gradually increases in brilliancy to a point about $\frac{1}{3}$ rd its apparent width from its outer edge, where it becomes suddenly bright. C. At times it is impossible to recognise any traces of this ring on the *p* side, though the *f* ansa is obvious enough. During the best definition, however, three or four large dusky areas are just distinguishable amid the general blackness of the space between the ball and the *p* ansa of B. *f* ansa very dark, but traceable. *Belts*.—Details well seen. *Shadow of ball*.—Extremely sharp; notch very evident; shadow falling on B slightly concave towards the east, becoming gradually wider from the notch to the outer edge of A.

16th March, 8^h 15^m to 9^h 15^m. Frosty; E. wind. Definition variable, but at times excellent, affording superb views of the planet. Powers used, 284, 350. *Rings*.—A. When seen to the greatest perfection it seems to be of a lavender-grey hue, the *p* ansa being slightly darker and the *f* ansa much darker than the dusky northern edge of the equatorial belt. Encke's division is seen on the *p* side only; here it is an easy object, and can be followed for some distance round the ansa. During the most favourable glimpses both ansæ appear to be striated with faint concentric markings. B. The brilliant outer edge of this ring causes it apparently to stand up like a step in front of Cassini's division. The graduated shading is not so evident to-night. It seems to occupy about $\frac{2}{3}$ rds of the width of the ring. C. The anomalous appearance of the *p* ansa again observed with both eyepieces. *f* ansa dark, but easily seen. *Belts*.—Equatorial zone covered with minute white spots on an orange-yellow background, and exhibiting much ill-defined detail. Its northern boundary consists of a dark band of irregular width, with a sharply-defined edge towards the north. The southern limit of the zone is marked by a similar but much fainter band. Polar cap, bluish-grey. A suspicion of two or three finer belts between this and the equatorial zone. About midway between the latter and the most northerly belt (which is partially hidden by C) there is a faint band, which at 9^h extended from the eastern limb across nearly three-fourths of the visible disc. That portion of the ball between the equatorial zone and C is much brighter and more decidedly yellow than the brightest part of the ring-system, viz. the outer portion of B.

18th March, 8^h to 9^h. Wind E. Definition excellent. Powers used, 284, 350. *Rings*.—A. Encke's division steadily seen on both ansæ, and occasionally glimpsed all round the ring, though it is more distinct on the *p* ansa than elsewhere; here it is bordered on the inner side by a faint narrow light edge. B. As on March 16th. C. The anomalous condition of the *p* ansa very evident with both eyepieces; as on February 26th, it

exhibits a deeply jagged or indented edge, while there is a wide black space on the *sp* side concentric with B and adjoining it.* *f* ansa very obscure, but visible. *Belts*.—All the detail seen on the 16th inst. observed to great perfection. Faint band north of equatorial zone again visible, but it could only be clearly traced from the east limb to the centre.



Saturn, 18 March, 1887, 8^h to 9^h. Thos. Gwyn Elger.

24th March, 9^h to 10^h. Definition not good. Power used, 350. *Rings*.—A. No detail visible. C. Irregular outline of inner border in *p* ansa traceable, but ring very dark and indistinct. *f* ansa apparently normal, but very obscure.

7th April, 9^h to 9^h 30^m. Definition variable—very good at times. Powers used, 284, 350. *Rings*.—A. No detail visible. C. The unsymmetrical inner border of the *p* ansa very conspicuous and remarkable as exhibiting a scalloped edge. The boundary between this ansa and B very ill-defined—so much so that it is difficult, as regards the *sp* portion, to trace any definite line of demarcation. *f* ansa very dark, hardly distinguishable from the space between ball and ring. *Belts*.—All well seen. Faint belt north of equatorial zone glimpsed once or twice on the *f* side of the centre. *Shadow of ball*.—Notch at Cassini's division seems decidedly blunter than it did a fortnight ago. The outer border of the shadow on A now runs up to the extreme point of the notch. The outline of the shadow both on A and B is evidently concave towards the east.

10th April, 8^h 20^m to 9^h 10^m. Wind E. Definition variable, but at times excellent. Powers used, 284, 350, and 420. *Rings*.—A. No detail seen. B. As on 16th March. C. Irregular inner border of *p* ansa evident with all the eyepieces used, and a dark interval between C and B extending for some distance on either side the apparent major axis of the ring. Three or four dusky spots noticed on the surface of *f* ansa. These features satisfactorily seen with all powers. *Belts*.—Details finely seen,

* See accompanying drawing.

but no trace of delicate belt north of equatorial zone, observed on March 16th and 18th and on 7th April. *Shadow of ball.*—As the notch now projects very little beyond the outline of the shadow, it is very difficult to make out.

11th April, 8^h 30^m to 8^h 55^m. Definition variable. Fine clear night; wind E. Powers used, 284, 350. *Rings.*—A. No detail seen. C. Irregular border glimpsed several times on *p* ansa. *f* ansa very obscure.

14th April, 8^h 30^m to 9^h 0^m. Definition excellent. Wind N.E. Powers used, 284, 350, 420. *Rings.*—A. Encke's division steadily seen on both ansæ. B. As on 16th March. C. With all the eyepieces the inner edge of the *p* ansa is clearly serrated. Dark spots again visible on *f* ansa. *Belts.*—Beautifully distinct; faint belt north of equatorial zone, first seen on 16th March, traced from limb to limb.

20th April, 8^h 20^m to 9^h 0^m. Definition pretty good. Powers used, 284, 350. *Rings.*—A. No detail visible. C. Both ansæ very dark. Irregular border of *p* ansa evident. The surface of ring in *f* ansa is manifestly irregular in tone, though no definite spots can be distinguished.—*Belts* not favourably seen. *Shadow of ball.*—It requires some attention to see the notch this evening; even at times of best definition there is hardly a recognisable projection at the Cassini division.

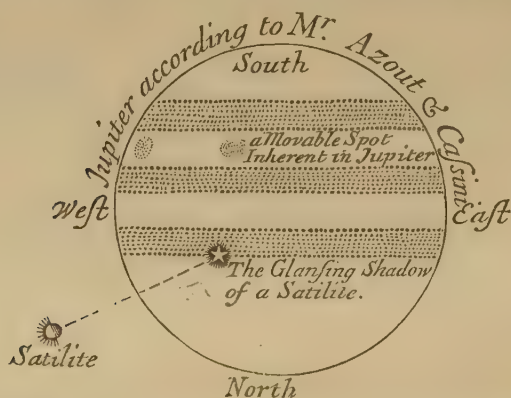
After this date, though several observations were attempted, the increasing duration of twilight and unfavourable weather prevented the details of the planet from being seen to advantage.

Kempston, Beds:
1887, June 6.

On an old Engraving of Jupiter. By Captain W. Noble.

The other day, in the valuable library of old astronomical works belonging to my friend Mr. C. Leeson Prince, F.R.A.S., I came across a curious little volume, described on its title-page as “Atlas Cœlestis, containing the Systems and Theories of the Planets, the Constellations of the Starrs. Sold by Ben Bragg in Paternoster Row.” Neither the author's name nor the date of publication is appended; but the name of “John Seller” appears in the corner of one of the plates, and, from a note in the body of the work with reference to an eclipse, it must have been published in 1680. Presumably this is the same John Seller who was the author of a quarto treatise on navigation which appears in the catalogue of our own library, and who produced a variety of books on arithmetic, astronomy, and navigation between the years 1671 and 1711. My immediate object, however, is to invite attention to one of Mr. Seller's engravings, which, through the kindness of Mr. Prince, I am able to reproduce in fac-simile.

The interest which I conceive to attach to this resides in the fact that the "movable spot inherent in *Jupiter*" shown in this old engraving is situated in precisely the same part of the planet's disc as the familiar red spot which has been watched of late years by so many scores—not to say hundreds—of observers. I have no means of access to Auzout's observations; but the early volumes of the *Philosophical Transactions* contain several notices of those of Cassini; and I have little doubt that one in the first volume (January 8, 1666), p. 143—"Of a permanent spot in *Jupiter*, by which is manifested the conversion of *Jupiter* about his own axis"—has reference to the very marking which Sellers draws. The words are these: "Besides that transient shadow" (of a satellite) "last mentioned * there hath been observed by Mons. Cassini a permanent spot in the disque of



Jupiter; by the help whereof he hath been able to observe not onely that *Jupiter* turns about upon his own axis, but also the time of such conversion, which he estimates to be $9^h\ 56^m$." Again, on p. 172 of the same volume (February 1666), after speaking of changes in "the three obscure belts" of *Jupiter* detected by Cassini, the account goes on to say that he (Cassini) "hath at length discovered a permanent spot in the northern part of the most southern belt, by the means whereof he hath concluded that *Jupiter* turns about his axis in 9 dayes" (an obvious *lapsus* for hours) "56 minutes." This is followed by a somewhat elaborate argument to show that the spot is actually attached to the surface of the planet, from the different manner in which it and the shadow of a satellite behave in traversing *Jupiter's* disc; and then the account goes on to say that Cassini "hath calculated many tables whereof he gives the explication and use in the letters by him addressed to the Abbot Falconière. By the means of them one may know when this spot may be seen by us . . . and shews by his tables what is to be added or

* This is, I suspect, the "Glancing Shadow of a Satilite" of the engraving.—W. N.

subtracted to know at what time the said spot is to come into the middle of *Jupiter's* diske." In all of which Cassini only anticipated Mr. Marth by two hundred years or so. In connection with this it is noteworthy that in the year 1858 a remarkable dark spot appeared upon the face of *Jupiter*, in the same part of his disc. My first intention was to have copied a drawing of my own, made at this date, to illustrate this, but I find one by Mr. Lassell on p. 52 of vol. xix. of the *Monthly Notices*, in which the spot is depicted. Putting all this together, it would appear that a permanent source of disturbance exists in a very circumscribed region to the south of *Jupiter's* equator, and that in observing the red spot we are probably only watching the marking by which the first determination of *Jupiter's* period of rotation was ever made.

On Prof. G. W. Hill's Paper on Delaunay's Method.
By Edmund Neison.

It had been my intention to have passed over in silence Prof. Hill's paper in the November number of the *Monthly Notices*, entitled, "A Reply to Mr. Neison's Strictures on Delaunay's Method of Determining the Planetary Perturbations of the Moon;" but it has been pointed out to me that, as the question involved is one which cannot readily be followed by most astronomers, it is proper that I should make known my dissent from the superficial criticisms urged by Prof. Hill, based as they are on so much misconception, betraying as they do such imperfect acquaintance with the previous history of the question, and supported as they are by no evidence beyond strong unsupported assertion. The whole paper is unjustifiable, unless we accept as incontrovertible the point of view from which the whole is written—namely that, because I differ from Delaunay, I must have a confused, erroneous conception of his method, and must be entirely in the wrong! The very keynote to the tone of the paper is given in almost the opening paragraph, that "If we were obliged to admit the validity of *all* the statements in this article, an easy corollary from them would be that Lagrange's general method of the variation of arbitrary constants in the problems of mechanics was a blunder. Now, I think that no one acquainted with this method could, for a moment even, entertain such a proposition. Hence, we may conclude there is some flaw in the reasoning of this paper." As a simple assertion this is strong enough and, polemically, may be good, but if Prof. Hill undertakes to substantiate his assertion it will be *he* who will have made the blunder.

I do not wish even to seem wanting in courtesy to Prof. Hill, whose valuable contributions to the Lunar Theory have always commanded my warmest admiration; but I cannot admit that the objections raised by him in this paper are such as to call for any serious reply.

Perhaps there are two points which might be noticed.

1. Prof. Hill's justification of Delaunay is singularly enough the simple reiteration of the unquestionable error dealt with in my very paper, where I clearly showed that it was no justification of Delaunay to say that he neglected these quantities depending on m^4 , m^5 , m^6 , m^7 . . . , because they were beyond the order of approximation fixed by him, and seemed obviously to be very small, because in the face of Hansen's explicit statement that, according to his calculations, it was these terms and these only which yielded the large values found by him, Delaunay was bound to so fix the order of his approximations that these terms were included. For remember that Delaunay was verifying Hansen's results; he was bound to include all included by Hansen, and in interpreting Hansen's statements was bound to assign Hansen's meaning to Hansen's words; so it is useless to try to evade the difficulty, as Prof. Hill does on p. 2, by assigning to Hansen's words a new and forced meaning that was never employed by Hansen or any of his contemporaries.

2. Prof. Hill points out how amusing it would be if it should "turn out that the set of values withheld from publication by Hansen were identical with those of Delaunay." Amusing! Very! in the face of Hansen's letter to Leverrier shortly before his death, in which he again expresses his complete disagreement with Delaunay's results, and his conviction from his calculations that, despite Delaunay, both the terms in question had sensible coefficients.

The question at issue may be stated thus:

By the ordinary direct methods of dealing with this problem, methods whose soundness, simplicity, and adequacy is unquestionable, there are obtained in the value of these coefficients certain quantities of the order m^6 , m^7 . . . depending on the higher powers of the disturbing force, which give rise to sensible values to these terms of long period. By the use of Delaunay's complex method neither he nor his followers have been able to obtain these terms. They argue—We do not obtain them, therefore they cannot exist. Hence, you ought not to get them by the ordinary direct methods, consequently those you do get must really disappear in some unexplained manner. The reply is—No; the onus of proving this disappearance lies with you; if you cannot derive them from your special method, the presumption is that you are not properly using your special method, so it is yielding you imperfect results.

Having now explicitly expressed my dissent from Prof. Hill's criticisms, I shall defer all further remarks to my Memoir on this subject, when I will show still more explicitly than I have yet done how Delaunay's application of his method to the computation of these terms is vitiated by an implicit assumption analogous in principle to that which would be made by assuming

$$f(R . R' + R'') = f(R . R') + f(R . R'').$$

Natal Observatory:

1887, April 11.

Note on the Performance of the Westminster Clock.
By Thomas Buckney.

The reputation of the great clock of the Houses of Parliament is so well established that some adequate reason must be given to justify any further reference to its performance here. This will, I think, be furnished by an inspection of its error from Greenwich time on each day of the period under review, viz., from March 29 last until June 9. The clock, as is well understood, is not allowed to run for an indefinite time with an accumulated error like an astronomical clock, but is kept as close to Greenwich time as possible, the necessary correction being made as soon as the error reaches 2 seconds either fast or slow. The pendulum is never stopped for this purpose, but alterations of rate are effected by the addition or removal of small weights in such a way as practically to shorten or lengthen the pendulum, whilst errors of 4 seconds or more are corrected by stopping the train of wheels or allowing them to run on for a few seconds as may be necessary. Four seconds is, however, the smallest alteration that can be made in this way. Now the clock, which, in common with most others in the country, was stopped by the snowstorm of Dec. 26 last (the snow having blocked the path of the hands), had since been going very well, requiring, however, small corrections from time to time. The last of these was made on March 29, and since that day no alteration or correction whatever has been made.

The following table shows the daily error of the clock since that time, and the figures, which have been kindly furnished by the Astronomer Royal from the records of the Royal Observatory, may be taken as authentic. It should be mentioned that the clock automatically reports itself by electric current to the Royal Observatory twice daily:

1887.	secs.	1887.	secs.	1887.	secs.	1887.	secs.
March 29	-0'0	April 9	-2'0	April 20	-1'0	May 1	-1'0
30	-0'0	10	-*	21	-2'0	2	-2'0
31	-1'0	11	-1'0	22	-2'0	3	-1'0
April 1	-1'0	12	-1'0	23	-1'0	4	-1'0
2	-1'0	13	-1'0	24	-1'5	5	-1'0
3	-3'0	14	-1'0	25	-2'0	6	-1'0
4	-2'0	15	-1'0	26	-1'0	7	-1'0
5	-2'0	16	-1'0	27	-1'5	8	-1'0
6	-2'0	17	-1'0	28	-2'0	9	-1'0
7	-2'0	18	-1'0	29	-1'5	10	-1'0
8	-*	19	-1'0	30	-1'5	11	-2'0

* No observation taken on these days.

1887.	secs.	1887.	secs.	1887.	secs.	1887.	secs.
May 12	-2'0	May 20	-2'0	May 27	-2'0	June 3	-1'0
13	-2'0	21	-2'0	28	-2'0	4	-1'0
14	-2'0	22	-2'0	29	-1'0	5	-0'0
15	-2'0	23	-2'0	30	-1'0	6	-0'0
16	-2'0	24	-2'0	31	-2'0	7	-0'0
17	-2'0	25	-2'0	June 1	-1'0	8	+1'0
18	-2'0	26	-*	2	-1'0	9	+0'7
19	-2'0						

An inspection of these figures will show that on March 29 the clock was exactly to Greenwich time, and again on June 5, 6, and 7. In the meantime it had made small variations, its greatest error having been 3 seconds on April 3. The most remarkable part of the table is the period comprised between May 11 and May 28, the clock having maintained an error of 2 seconds without any variation whatever, and on 30 out of the 72 days its error was exactly 1 second—but these were not consecutive days—one group, however, of 10 days in succession being noted.

I believe this performance is unprecedented, so it may deserve to be placed on record.

1887, June 9.

P.S.—The clock is still 2 secs. slow, no correction having been required up to the present time, July 6th.

Note on the Orbit of Comet Ross (1883 II.) By Lieut.-General J. F. Tennant, R.E., F.R.S.

Mr. Bryant has pointed out two errors in the "Comparisons of the Observations of Mr. Ross's Comet (II. of 1883)" with my ephemeris, which would considerably affect the last normal place, and which, moreover, render the observations so much more accordant that it would now be worth while to get normals with more trouble. The gross result would possibly be to approximate to his orbit, and I hasten to recognise the defect of that I proposed.

* No observation taken on this day.